United States Department of Agriculture

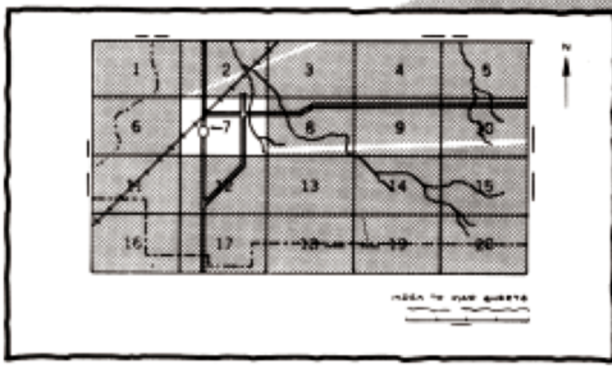
Soil Conservation Service

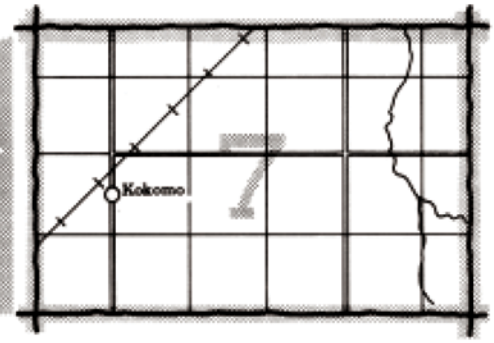
In cooperation with Guam Department of Commerce and University of Guam

Soil Survey of Territory of Guam

HOW TO USE

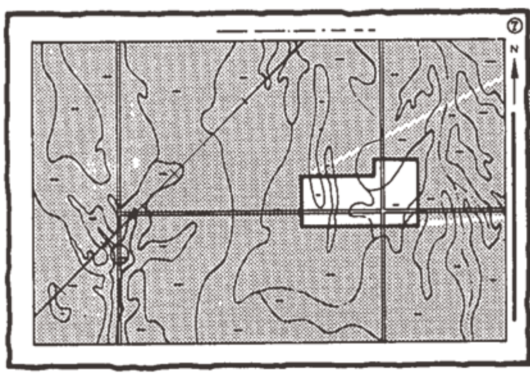
1. Locate your area of interest on the "Index to Map Sheets"

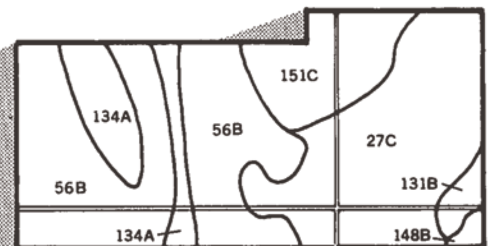




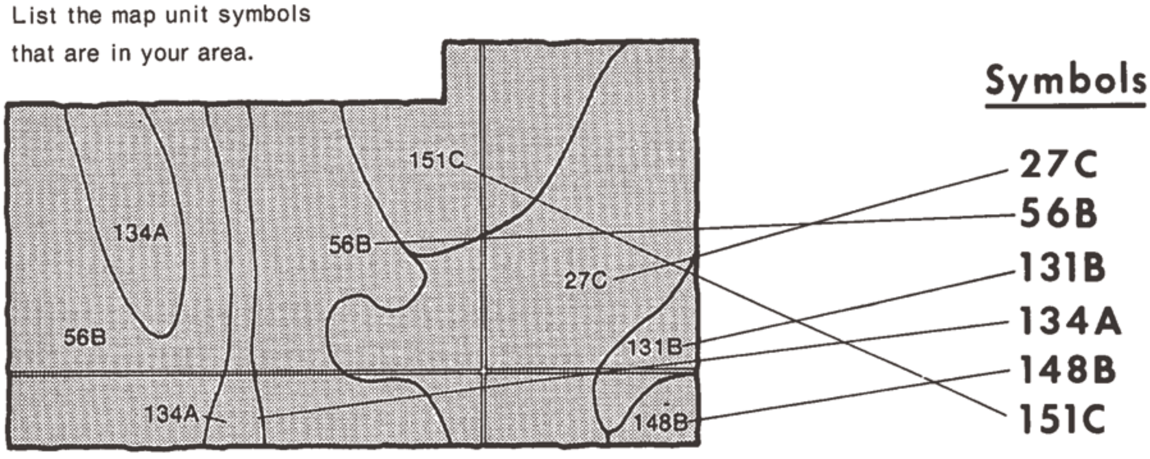
2. Note the number of the map sheet and turn to that sheet.

3. Locate your area of interest on the map sheet.



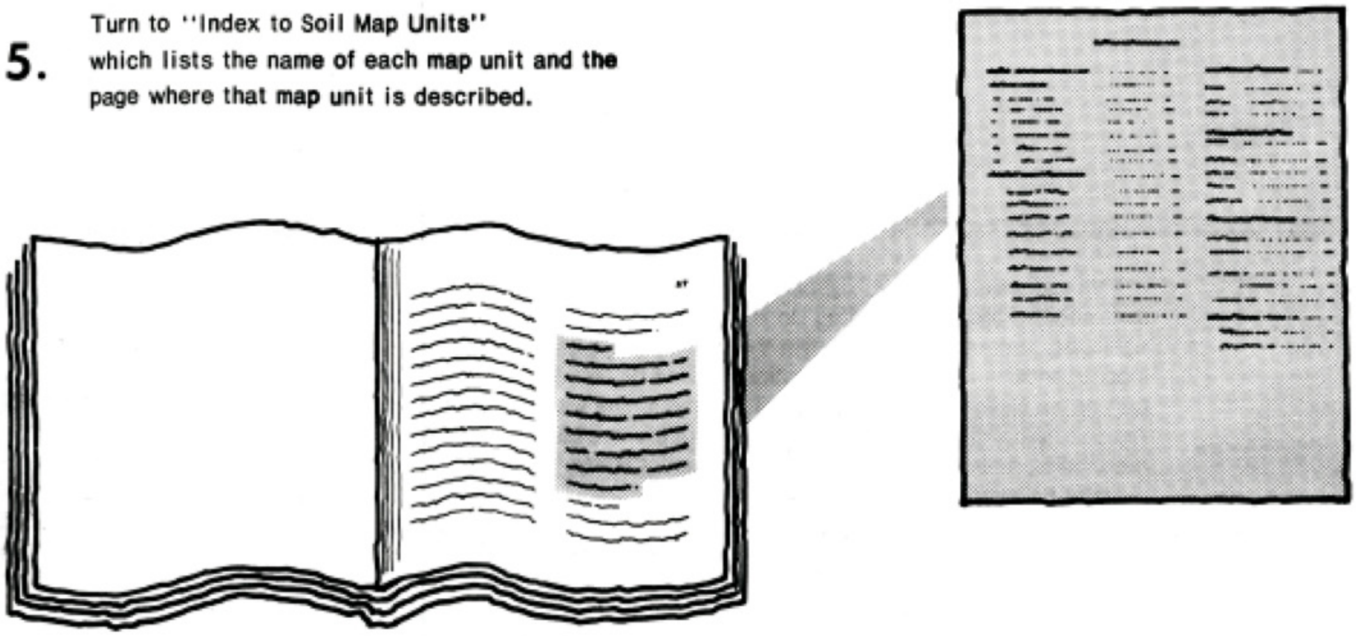


4. List the map unit symbols that are in your area.

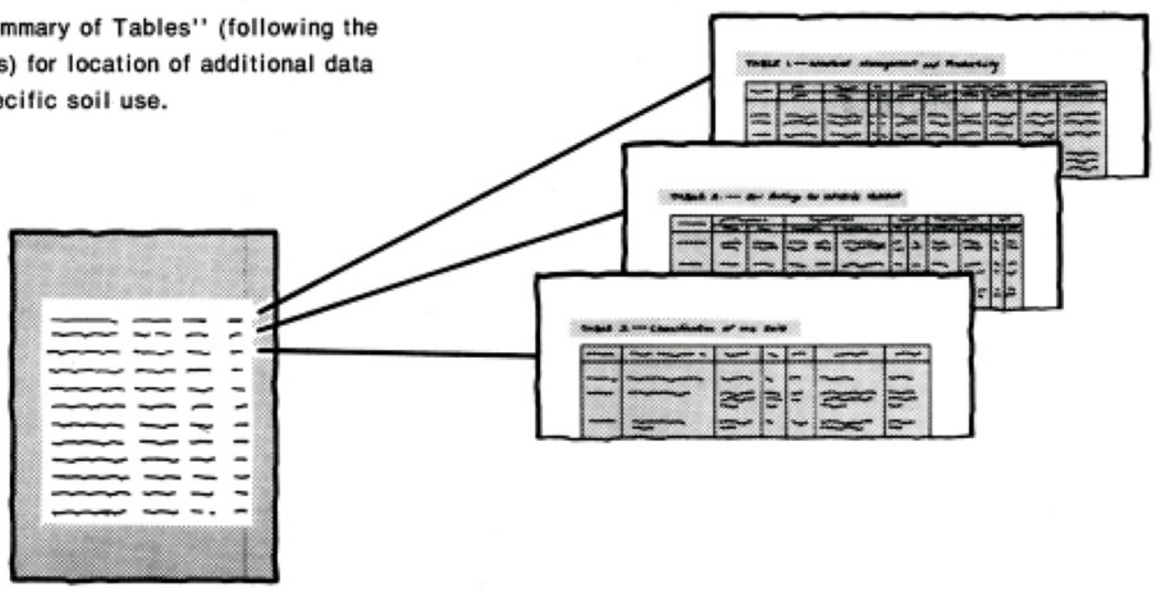


THIS SOIL SURVEY

5. Turn to "Index to Soil Map Units" which lists the name of each map unit and the page where that map unit is described.



6. See "Summary of Tables" (following the Contents) for location of additional data on a specific soil use.



7. Consult "Contents" for parts of the publication that will meet your specific needs. This survey contains useful information for farmers or ranchers, foresters or agronomists; for planners, community decision makers, engineers, developers, builders, or homebuyers; for conservationists, recreationists, teachers, or students; to specialists in wildlife management, waste disposal, or pollution control.

This soil survey is a publication of the National Cooperative Soil Survey, a joint effort of the United States Department of Agriculture and other federal agencies, state agencies including the Agricultural Experiment Stations, and local agencies. The Soil Conservation Service has leadership for the federal part of the National Cooperative Soil Survey. In line with Department of Agriculture policies, benefits of this program are available to all, regardless of race, color, national origin, sex, religion, marital status, handicap, or age.

Major fieldwork for this soil survey was completed in 1984. Soil names and descriptions were approved in 1985. Unless otherwise indicated, statements in this publication refer to conditions in the survey area in 1985. This survey was made cooperatively by the Soil Conservation Service, the University of Guam, and the Guam Department of Commerce. It is part of the technical assistance furnished to the Northern and Southern Guam Soil and Water Conservation Districts.

Soil maps in this survey may be copied without permission. Enlargement of these maps, however, could cause misunderstanding of the detail of mapping. If enlarged, maps do not show the small areas of contrasting soils that could have been shown at a larger scale.

Cover: Agfayan and Akina soils on Mount Schroeder, in southern Guam. Akina and Atate soils in foreground.

Contents

Soil Series

Issued May 1988

Index to Map Units

Summary of Tables

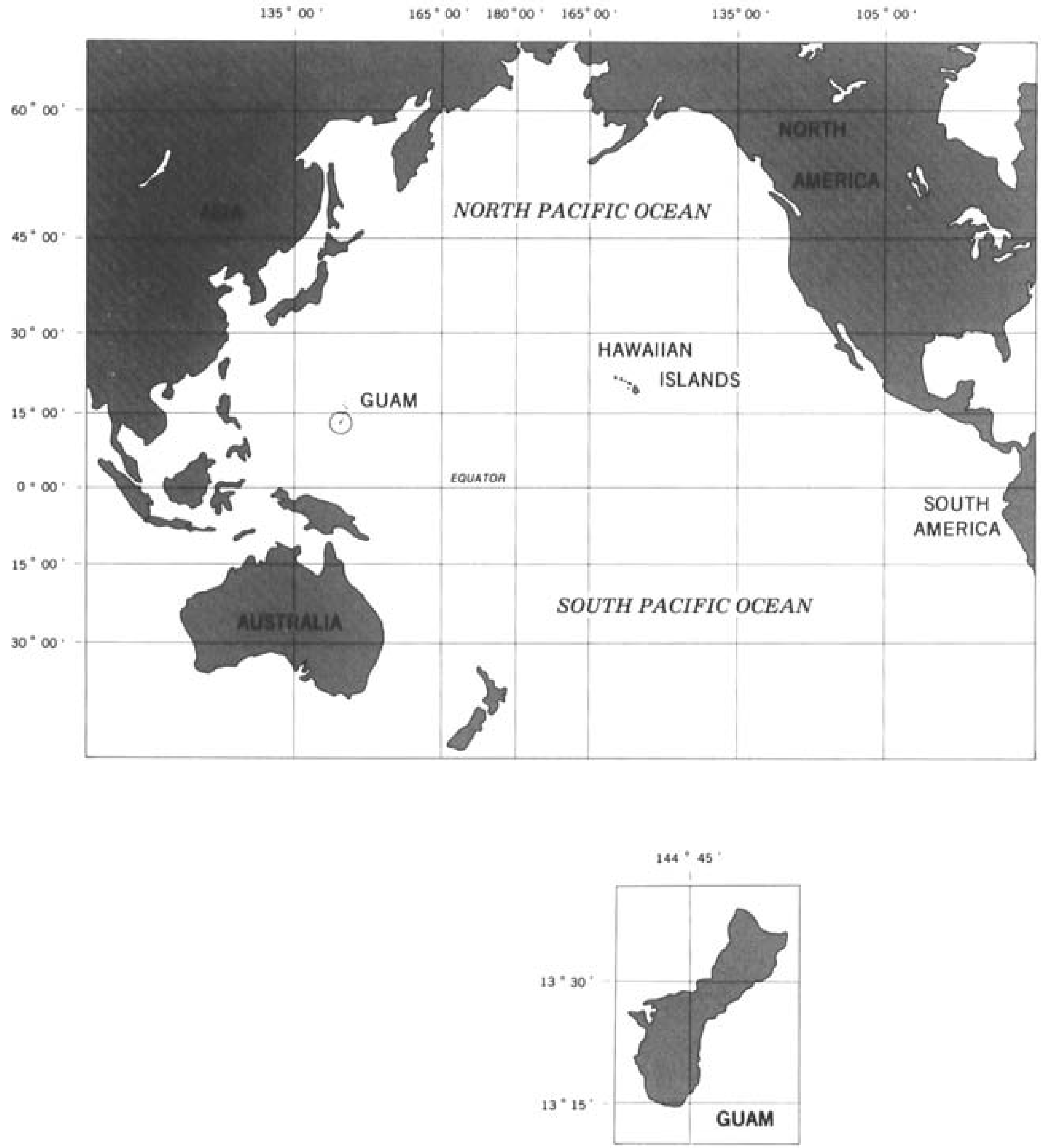
Foreword

This soil survey contains information that can be used in land-planning programs in the Territory of Guam. It contains predictions of soil behavior for selected land uses. The survey also highlights limitations and hazards inherent in the soil, improvements needed to overcome the limitations, and the impact of selected land uses on the environment.

This soil survey is designed for many different users. Farmers, ranchers, foresters, and agronomists can use it to evaluate the potential of the soil and the management needed for maximum food and fiber production. Planners, community officials, engineers, developers, builders, and home buyers can use the survey to plan land use, select sites for construction, and identify special practices needed to ensure proper performance. Conservationists, teachers, students, and specialists in recreation, wildlife management, waste disposal, and pollution control can use the survey to help them understand, protect, and enhance the environment.

Great differences in soil properties can occur within short distances. Some soils are seasonally wet or subject to flooding. Some are shallow to bedrock. Some are too unstable to be used as a foundation for buildings or roads. Clayey or wet soils are poorly suited to use as septic tank absorption fields. A high water table makes a soil poorly suited to basements or underground installations.

These and many other soil properties that affect land use are described in this soil survey. Broad areas of soils are shown on the general soil map. The location of each soil is shown on the detailed soil maps. Each soil in the survey area is described. Information on specific uses is given for each soil. Help in using this publication and additional information are available at the local office of the Soil Conservation Service or the Cooperative Extension Service.



Location of the Territory of Guam.

Soil Survey of
Territory of Guam

By Fred J. Young, Soil Conservation Service

Fieldwork by Fred J. Young and Saku Nakamura,
Soil Conservation Service

United States Department of Agriculture, Soil Conservation Service
In cooperation with
Guam Department of Commerce and University of Guam

The TERRITORY OF GUAM includes the largest and southernmost of the Mariana Islands, in the western part of the Pacific Ocean. The island of Guam is about 6,100 kilometers west-southwest of Hawaii and 2,600 kilometers east of the Philippines. The island is about 48 kilometers long and is 6 to 19 kilometers wide. The survey area also includes 12 small islands on the fringing reef, the largest of which is Cocos Island. The total area is 54,908 hectares, or about 549 square kilometers. Agana, the capital city, is on the western coast, in the narrow central part of the island. In 1980 the population of Guam was 110,000, of which about 20,000 were military persons and their dependents and civilian employees of the Department of Defense and their dependents.

The southern part of the island of Guam is characterized by mountainous uplands that are deeply dissected by numerous rivers. These rivers coalesce to form relatively wide valley bottoms near the coast and several narrow coastal plains. Most areas in the south are volcanic in origin, although limestone occurs along the southeastern coast and in a large area around Mount Lamlam and Mount Alifan. Mount Lamlam, at 407 meters elevation, is the highest point on the island.

The northern part of the island is a relatively flat limestone plateau that rises from about 30 meters in elevation in the south to about 174 meters in the north. There is no surface drainage on this plateau; all rainfall percolates directly into the permeable limestone.

The central part of the island is composed of rolling limestone hills and plateaus. The drainage system is only partially developed, and there are many closed depressional areas.

The soils of Guam have been mapped previously by Stensland (*17*) and by Park (*12*). Information from these older reports was used during the fieldwork for this report. Soil names were retained whenever feasible. The present survey, however, updates these earlier surveys and provides additional information and larger maps that show the soils in greater detail.

Differing levels of intensity were used during field mapping. Mountainous areas in southern Guam were more broadly defined. Boundaries were plotted and verified at wider intervals. No direct soil survey fieldwork was conducted on Andersen Air Force Base. Soil mapping in this area is based on the correlation of information from older reports, photo interpretation, observations on similar landscapes in private ownership, and limited field observations as part of technical assistance to the Division of Aquatic and Wildlife Resources, Department of Agriculture, Government of Guam.

General Nature of the Survey Area

This section provides general information about the survey area. It discusses history, local government, social and economic setting, land use and ownership, and climate.

History

There is evidence that Guam was first settled around 2,000 B.C. by the Chamorro people, a unique group from the fringes of southeast Asia. Guamanians today represent many races and nationalities (*13*).

Guam was discovered by Magellan in 1521, and from that time on it was visited by an increasing number of outsiders. The island became an important link in the Spanish economic and political system. In 1668 the Spanish established the first permanent white settlement, which remained under their jurisdiction until 1898. The Spanish-Chamorro wars greatly reduced the population. During the eighteenth century, the population increased as a result of intermarriage of the Spanish with the local population and the immigration of Japanese, Filipinos, and other nationalities.

The island remained under Spanish rule until the end of the Spanish-American War in 1898. Efforts were made to attain agricultural self-sufficiency and to improve the water supply, health standards, and education. Spanish culture and tradition continue to be an important part of Guamanian life.

On December 10, 1941, the island was surrendered to invading Japanese forces. Americans recaptured the island in July, 1944, and reinstated a naval military government. A milestone was reached in the political history of Guam when the President signed the Organic Act into law in 1950. The law extended American citizenship to the people of the island, and it made Guam a territory of the United States, providing for the transfer of the naval administration to civilian hands. In 1970 the Governor became an official elected by popular vote, and in 1972 voters elected a delegate to the U.S. House of Representatives.

Local Government

The local government of Guam is similar to the Federal government. The executive branch is headed by the Governor, who is responsible for executing the laws of Guam and the laws of the United States that are applicable to Guam. The Governor and Lieutenant Governor are elected on the same ticket. The unicameral legislature of Guam is composed of 21 senators. The senators are elected at large every 2 years. The judiciary branch is composed of a Federal District Court and the Superior Court of Guam. There are 19 municipalities, or villages, on Guam. Voters elect a commissioner for each village. The commissioners' post is similar to that of a mayor. Commissioners meet every week in the Commissioners Council.

Social and Economic Setting

The population of Guam is about 110,000, of which about 20,000 are military persons and their dependents and civilian employees of the Department of Defense and their dependents. The median age is 20 years. Overall, the population includes fewer older people and more under the age of 6 years than does that of the mainland United States. The Government of Guam anticipates that a large number of people will be entering the work force in the future and that much more pressure will be placed on living space, recreation facilities, water, transportation facilities, and environmentally sensitive areas. The extra pressure for development will fall on the best agricultural land in the northern part of Guam—the land now shown on planning maps as a conservation district.

The government is the largest employer on Guam. The Government of Guam is expected to grow as population increases. The military is expected to maintain a constant presence, at least in the near future. Wholesale and retail trade and construction are also major sources of employment. The service, transportation, and financial industries are next in importance. Manufacturing and agriculture have employed only a limited number in recent years.

Traditional Guamanian society has a village-church orientation. The extended family is the extent of social activity. In the north, more families are becoming isolated from the extended family group, but family oriented activities such as fiestas, fandangoes, christenings, and funerals are still the most important social interactions.

Land Use and Ownership

About 47 percent of Guam is privately owned, 35 percent is federally administered, and the remaining 18 percent is administered by the Government of Guam.

The Government of Guam leases much land for agricultural use. Both annual and long-term leases are available. Many commercial farmers have long-term leases with the Government for several hectares. Short-term leased lands commonly are used as residential lots with gardens. The land use plan of Guam discourages residential development and excessive land grading in these areas.

Aquaculture is another important land use. There are presently about 10 operations; each has 0.5 to 2.0 hectares of ponds. Tilapia is the main aquacultural product. Freshwater prawns, milkfish, catfish, and carp are also cultivated. Actual production is quite variable from year to year.

At present, only 5 hectares of the survey area is used as pasture. It is in areas of Guam cobbly clay loam and is planted primarily to napiergrass and guineagrass.

Climate

Information for this section was provided by the National Oceanographic and Atmospheric Administration.

The climate of Guam is almost uniformly warm and humid throughout the year. Afternoon temperatures

typically are about 30 degrees C, and nighttime temperatures typically fall to the low 20's. Relative humidity commonly is 65 to 75 percent in the afternoon and ranges to 85 to 100 percent at night. Though temperature and humidity vary only slightly throughout the year, rainfall and wind conditions vary markedly, and it is these variations that define the seasons.

There are two primary seasons and two secondary seasons on Guam (fig. 1). The primary seasons are the 4-month-long dry season, which extends from January through April, and the 4-month-long rainy season, which extends from mid-July to mid-November. The secondary seasons extend from May to mid-July and from mid-November through December. These are transitional seasons that can be either rainy or dry, depending on the nature of the particular year. The rainfall distribution is seasonal, and moisture deficit occurs between January and June.

The mean annual rainfall on Guam ranges from about 250 centimeters on the windward, or east, side of the higher mountains to about 200 centimeters along the coast of the west side of the southern half of the island. On an average, about 15 percent of the annual rainfall occurs during the dry season and 55 percent during the rainy season.

Throughout the year, the dominant winds on Guam are the trade winds that blow from the east or northeast. The trade winds are strongest and most constant during the dry season, when windspeeds of 25 to 40 kilometers per hour are very common. A breakdown of the trade winds commonly occurs during the rainy season, and on some days the weather may be dominated by westerly-moving storm systems that bring heavy showers or steady, and sometimes torrential, rains. Occasionally there are typhoons, and these bring not only extremely heavy rains, but also violent winds that may result in a surge of water onto low-lying coastal areas. Since 1908, typhoons have passed close enough to Guam to produce high winds and heavy rains in every month, but they occur most frequently during the latter half of the year. The chance of having one or more typhoons pass within this distance in any particular year is about once in 3 years. The chance of having a typhoon move directly across Guam, however, is only about once in 8 years.

How This Survey Was Made

This survey was made to provide information about the soils and miscellaneous areas in the survey area. The information includes a description of the soils and miscellaneous areas and their location and a discussion of their suitability, limitations, and management for specified uses. Soil scientists observed the steepness, length, and shape of the slopes; the general pattern of drainage; the kinds of crops and native plants; and the kinds of bedrock. They dug many holes to study the soil profile, which is the sequence of natural layers, or horizons, in a soil. The profile extends from the surface down into the unconsolidated material in which the soil formed. The unconsolidated material is devoid of roots and other living organisms and has not been changed by other biologic activity.

A tile spade and hand-operated bucket auger were the basic tools used in field mapping. Depth of observation with these tools did not exceed 2 meters, although slumps and road cuts allowed for some deeper observations. Soil pits used to sample and describe representative soil profiles were dug by hand or with a backhoe.

The soils and miscellaneous areas in the survey area are in an orderly pattern that is related to the geology, landforms, relief, climate, and natural vegetation of the area. Each kind of soil and miscellaneous area is associated with a particular kind or segment of the landscape. By observing the soils and miscellaneous areas in the survey area and relating their position to specific segments of the landscape, a soil scientist develops a concept or model of how they were formed. Thus, during mapping, this model enables the soil scientist to predict with considerable accuracy the kind of soil or miscellaneous area at a specific location on the landscape.

Individual soils on the landscape commonly merge gradually onto one another as their characteristics gradually change. To construct an accurate map, however, soil scientists must determine the boundaries between the soils. They can observe only a limited number of soil profiles. Nevertheless, these observations, supplemented by an understanding of the soil-vegetation-landscape relationship, are sufficient to verify predictions of the kinds of soil in an area and to determine the boundaries.

Soil scientists recorded the characteristics of the soil profiles that they studied. They noted color, texture, size, and shape of soil aggregates, kind and amount of rock fragments, distribution of plant roots, reaction, and other features that enable them to identify soils. After describing the soils in the survey area and determining their properties, the soil scientists assigned the soils to taxonomic classes (units). Taxonomic classes are concepts. Each taxonomic class has a set of soil characteristics with precisely defined limits. The classes are used as a basis for comparison to classify soils systematically. Soil taxonomy, the system of taxonomic classification used in the United States, is based mainly on the kind and character of soil properties and the arrangement of horizons within the profile. After the soil scientists classified and named the soils in the survey area, they compared the individual soils with similar soils in the same taxonomic class in other areas so that they could confirm data and assemble additional data based on experience and research.

While the soil survey was in progress, samples of some of the soils in the area were collected for

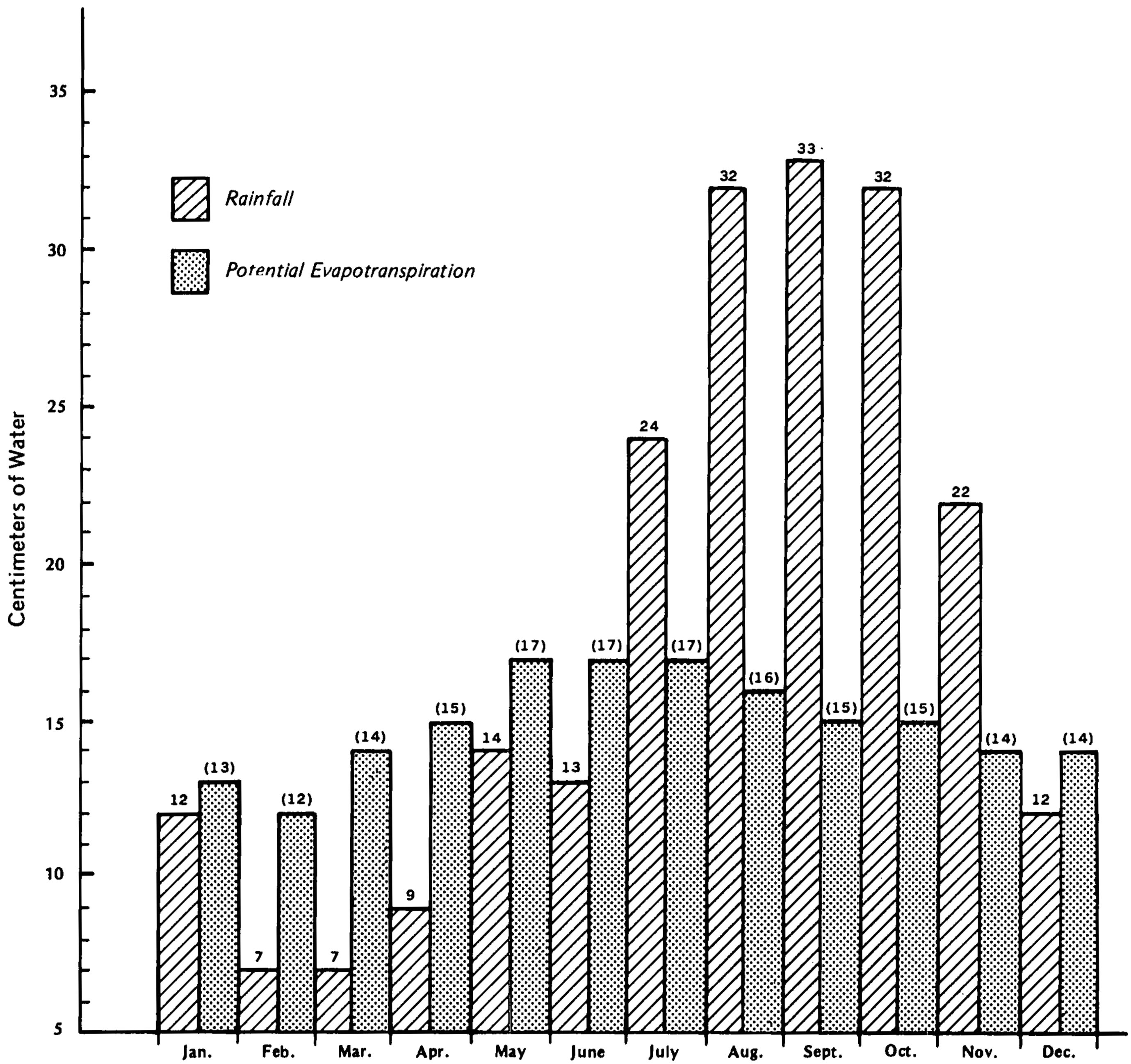


Figure 1.—Rainfall and potential evapotranspiration data at Agana, as calculated by the modified Thornwaite method (*8*).

laboratory analyses and for engineering tests. Soil scientists interpreted the data from these analyses and tests as well as the field-observed characteristics and the soil properties to determine the expected behavior of the soils under different uses. Interpretations for all of the soils were field tested through observation of the soils in different uses and under different levels of management. Some interpretations were modified to fit local conditions, and some new interpretations were developed to meet local needs. Data were assembled from other sources, such as research information, production records, and field experience of specialists.

Predictions about soil behavior are based not only on soil properties but also on such variables as climate and biological activity. Soil conditions are predictable over long periods of time, but they are not predictable from year to year. For example, soil scientists can state with a fairly high degree of probability that a given soil will have a high water table within certain depths in most years, but they cannot predict that a high water table will always be at a specific level in the soil on a specific date.

After soil scientists located and identified the significant natural bodies of soil in the survey area, they drew the boundaries of these bodies on aerial photographs and identified each as a specific map unit. Aerial photographs show trees, buildings, fields, roads, and rivers, all of which help in locating boundaries accurately.

General Soil Map Units

The general soil map at the back of this publication shows broad areas that have a distinctive pattern of soils, relief, and drainage. Each map unit on the general soil map is a unique natural landscape. Typically, a map unit consists of one or more major soils or miscellaneous areas and some minor soils or miscellaneous areas. It is named for the major soils or miscellaneous areas. The soils or miscellaneous areas making up one unit can occur in other units but in a different pattern.

The general soil map can be used to compare the suitability of large areas for general land uses. Areas of suitable soils or miscellaneous areas can be identified on the map. Likewise, areas that are not suitable can be identified.

Because of its small scale, the map is not suitable for planning the management of a farm or field or for selecting a site for a road or building or other structure. The soils in any one map unit differ from place to place in slope, depth, drainage, and other characteristics that affect management.

The general map units in this survey have been grouped into general kinds of landscape for broad interpretive purposes. Each of the broad groups and the map units in each group are described in the following pages.

Map Unit Descriptions

Soils on bottom lands

This group consists of one map unit. It makes up about 4 percent of the survey area.

1. Inarajan-Inarajan Variant

Deep and very deep, somewhat poorly drained and poorly drained, level and nearly level soils; on valley bottoms and coastal plains

This map unit is in the major valleys in the central and southern parts of Guam. It is also on coastal plains along the southern coast and extends from Agat to Piti on the western coast. This unit is characterized by rivers and streams that are incised 1 meter to 10 meters into the landscape. Slope is 0 to 4 percent. The vegetation in areas not cultivated is mainly water tolerant forest and grasses such as *Phragmites karka* and *Brachiaria mutica*.

This unit makes up about 4 percent of the survey area. It is about 70 percent Inarajan soils and 15 percent Inarajan Variant soils. The remaining 15 percent is components of minor extent.

Inarajan soils are in nearly level areas on lower valley bottoms in major valleys in southern Guam and on coastal plains (fig. 2). These soils are deep and very deep and are somewhat poorly drained. They formed in alluvium derived dominantly from volcanic material and marine sediment. The soils are clay throughout. During the rainy period, these soils are saturated and are subject to flooding. The water table recedes during the dry period.

Inarajan Variant soils are on coastal plains along the western coast. These soils are very deep and poorly drained. They formed in alluvium derived dominantly from volcanic material and marine sediment. The soils are clay throughout. Thin layers of organic material are in most profiles. A permanent water table fluctuates between the surface and a depth of about 50 centimeters below the surface. This soil is subject to very long periods of flooding in the rainy season.

Of minor extent in this unit are 5 percent Shioya soils, 5 percent Urban land and Ustorthents, and 5 percent Troposaprists, Ylig soils, and various upland soils. Shioya soils are sandy and excessively drained and are along the eastern part of the southern coast. The areas of Urban land and Ustorthents consist of paved, urbanized areas and fill areas and are in villages and on military installations. Troposaprists are very poorly drained organic soils and are in Agana Swamp. Ylig soils are acidic alluvial clay and are in narrow drainageways upstream from areas of Inarajan soils.

This unit is used as cropland and homesites, for urban development, and as wildlife habitat and watershed.

This unit is suited to dry season agriculture in areas where the water table recedes. Watermelon and bananas are the main crops grown. Most areas are well suited to aquaculture. The level and nearly level slopes and the geographic location of the unit make it suitable for use as homesites and for road construction and some commercial development. The limitations of flooding, soil wetness, and low soil strength must be overcome for successful urban development.

This unit is well suited to wetland wildlife habitat; it includes most of the wetland in the survey area. Open water and plant cover are important habitat components for species such as the endangered Mariana gallinule. Practices that increase the extent and duration of open

water areas while maintaining the surrounding vegetation improve wetland wildlife habitat.

Soils on volcanic uplands

This group consists of two map units. It makes up about 35 percent of the survey area.

2. Akina-Agfayan

Very shallow to very deep, well drained, moderately steep to extremely steep soils; on strongly dissected mountains and plateaus

This map unit is in the southern part of the survey area and on Mount Santa Rosa, in the northern part. This unit is characterized by deeply dissected narrow plateau remnants and jagged mountains (fig. 3). Drainageways typically are narrow and dendritic. Most slopes are broken by either slumps or areas of Rock outcrop. Slope is 15 to 99 percent. The vegetation is mainly savannah plants, but extensive areas are forested. Most forested areas are on sheltered leeward and lower lying slopes.

This unit makes up about 30 percent of the survey area. It is about 45 percent Akina soils and 30 percent Agfayan soils. The remaining 25 percent is components of minor extent.

Akina soils are on side slopes and ridgetops. These soils are very deep and well drained. They formed in

Figure 2.—Typical area of Inarajan soils in general soil map unit 1.

Figure 3.—Typical area of general soil map unit 2. Akina soils and Badland are in foreground. Mt. Sasalaguan is in background; Agfayan soils and Rock outcrop are on the steep slopes, and Akina soils are on the strongly sloping, tilted plateaus.

residuum derived dominantly from volcanic tuff or tuff breccia. The soils are red, acidic silty clay and clay and are underlain by saprolitic tuff at a depth of 51 to 102 centimeters.

Agfayan soils are on side slopes and ridgetops. These soils are very shallow and shallow and are well drained. They formed in residuum derived dominantly from marine deposited tuffaceous sandstone. The soils are slightly acid to neutral clay and are underlain by weathered bedrock at a depth of 10 to 38 centimeters.

Of minor extent in this unit are 15 percent Badland and Rock outcrop and 10 percent Ylig and Atate soils and some Togcha soils. Badland occurs in slump areas on the Akina soils and commonly is on ridgelines and shoulder slopes. Rock outcrop consists of exposures of volcanic rock and is closely associated with the Agfayan soils. It commonly is on ridgelines and upper side slopes. Ylig soils are in drainageways. Atate soils are primarily in forested areas and are closely associated with the Akina soils. Togcha soils are on lower lying slopes and in drainageways, commonly between areas of Akina and Ylig soils.

This unit is used as wildlife habitat and watershed.

This unit is poorly suited to agricultural or urban use. It is limited mainly by steepness of slope and a severe erosion hazard. Only small, isolated areas can be farmed or are suitable as homesites. Access to these areas commonly is very poor. Improperly designed and prepared roads are quickly rendered useless by erosion.

Wildfires are a major concern on this unit. Fire temporarily removes the plant cover, exposing the soil to the erosive action of rain. Fire also serves to maintain and increase the areas of savannah plants and reduce the areas of forest. This lowers the capacity of the unit to provide a constant, clean source of water because the rate of runoff is much higher under savannah plants than it is under forest.

3. Akina-Togcha-Ylig

Very deep, somewhat poorly drained and well drained, gently sloping to strongly sloping soils; on plateaus and in basins

This map unit is in the southern part of the survey area. It is characterized by broad ridges and weakly dissected plateaus and basins (fig. 4). Drainageways generally are not deeply incised, although a few steep-sided valleys are present. Slope is 3 to 30 percent. The vegetation in areas not cultivated is mainly savannah plants.

This unit makes up about 5 percent of the survey area. It is about 40 percent Akina soils, 25 percent Togcha soils, and 15 percent Ylig soils. The remaining 20 percent is components of minor extent.

Akina soils are on plateaus and upper side slopes. These soils are very deep and well drained. They formed in residuum derived dominantly from volcanic tuff or tuff breccia. The soils are red, acidic, and clayey and are underlain by saprolitic tuff at a depth of 51 to 102 centimeters.

Togcha soils are on lower lying slopes of rolling volcanic uplands. These soils are very deep and well drained. They formed in alluvial slopewash derived dominantly from saprolitic tuff and tuff breccia and eroded volcanic soils. The soils are red, acidic silty clay throughout.

Ylig soils are in drainageways and on seep slopes. These soils are very deep and somewhat poorly drained. They formed in alluvium derived dominantly from saprolitic tuff and tuff breccia and eroded volcanic soils. The soils are clay throughout.

Of minor extent in this unit are about 10 percent Agfayan soils and Rock outcrop and 10 percent Badland and Atate and Sasalaguan soils. Agfayan soils and Rock

Figure 4.—Typical area of general soil map unit 3. Akina soils are on the convex ridges and plateaus, Togcha soils are on the lower slopes, and Ylig soils are on the valley bottoms.

outcrop are along incised drainageways and on ridges and rounded hills. Badland occurs as slumps in areas of the Akina soils and is mainly on shoulder slopes. Atate and Sasalaguan soils are on plateaus.

This unit is used for crops, mainly watermelon. It is also used as watershed and wildlife habitat.

This unit is moderately suited to crops. It is limited mainly by the hazard of erosion. Many crops can be successfully grown in this unit with erosion control, good fertility management, including liming, and irrigation. In some areas access is poor.

This unit is moderately suited to homesites and road construction. It is limited mainly by low soil strength, seasonal wetness of the Ylig soils, and a hazard of erosion. Improperly designed and prepared roads are quickly rendered useless by ruts and gullies resulting from low soil strength and erosion.

Wildfires adversely affect use of this unit as watershed and wildlife habitat and contribute to the risk of erosion. Wildfires also destroy fencing, farm structures, equipment, and other property. Establishing firebreaks, restricting public access, and closely supervising controlled burns can help to reduce the incidence of wildfires.

Soils on limestone uplands

This group consists of five map units. It makes up about 61 percent of this survey area.

4. Guam

Very shallow, well drained, nearly level to moderately sloping soils; on plateaus

This map unit is in the northern part of the survey area. It is characterized by long, plane and gently undulating slopes with occasional steep escarpments. There are no drainageways in this unit. Slope is 3 to 15 percent. The vegetation in areas not cultivated is mainly forest.

This unit makes up about 23 percent of the survey area. It is about 90 percent Guam soils. The remaining 10 percent is components of minor extent.

Guam soils are red cobbly clay loam throughout. Porous limestone dominantly is at a depth of 10 to 25 centimeters.

Of minor extent in this unit are Yigo and Ritidian soils, Urban land, and Rock outcrop. Yigo soils are deep and very deep, well drained silty clay and are in depressional areas. They are important for crop production. Ritidian soils dominantly are less than 10 centimeters thick and are along steep escarpments and slope breaks. They are associated with areas of limestone Rock outcrop.

This unit is used for vegetables, urban development, wildlife habitat, and watershed.

This unit is poorly suited to crops; however, it is an important agricultural area. It is limited by the very shallow soil depth and droughtiness. Careful irrigation and fertilizer management are essential for crop production. Areas of the minor Yigo soils should be used wherever feasible.

This unit is poorly suited to urban development. It is limited by the very shallow depth to bedrock, which could interfere with excavation.

The ground water in this unit is the main water supply of the survey area. Runoff from urban areas, homesites, and agricultural operations should be closely monitored to prevent ground water contamination.

Some areas of this unit provide important wildlife habitat.

5. Guam-Urban land-Pulantat

Very shallow and shallow, well drained, level to gently sloping soils, and Urban land; on plateaus

This map unit is in the northern part of the survey area and on the western coast, including the Orote Peninsula. This unit is characterized by long, plane and gently undulating slopes with some steep escarpments, generally along the coast. There are very few drainageways in the unit. Slope dominantly is 0 to 7 percent, but it ranges to 15 percent.

This unit makes up about 14 percent of the survey area. It is 40 percent Guam soils, 40 percent Urban land, and 15 percent Pulantat soils. The remaining 5 percent is mostly Ritidian soils along steep escarpments.

Guam soils are very shallow and well drained. The soils are red cobbly clay loam throughout. Porous limestone dominantly is at a depth of 10 to 25 centimeters.

Urban land consists of areas covered by roads, buildings, parking lots, airfields, and other impervious surfaces.

Pulantat soils are shallow and well drained. The soils are clay and silty clay throughout. Argillaceous limestone is at a depth of 25 to 51 centimeters.

This unit is used for homesite and urban development, including airfields and military facilities. Some areas, such as the Northwest Field on Andersen Air Force Base, presently are not in use.

The main limitation of this unit for urban development is the depth to bedrock, which may interfere with excavations. Runoff from urban areas should be closely monitored to prevent ground water contamination.

6. Ritidian-Rock outcrop-Guam

Very shallow, well drained, gently sloping to extremely steep soils, and Rock outcrop; on plateaus, mountains, and escarpments

This map unit is along the coast in the northern and southeastern parts of the survey area and in some areas in the southern mountains. The northern part of the unit is characterized by steep escarpments adjacent to gently sloping plateaus. The southern part is characterized by

rounded karst topography. There are no drainageways in the north and very few in the south. Slope is 3 to 99 percent. The vegetation is native forest.

This unit makes up about 12 percent of the survey area. It is about 45 percent Ritidian soils, 35 percent Rock outcrop, and 15 percent Guam soils. The remaining 5 percent is components of minor extent.

Ritidian soils are very shallow and well drained. They are extremely cobbly clay loam that is dominantly less than 10 centimeters thick over porous limestone.

Rock outcrop occurs as jagged pinnacles and sheer cliff faces of unweathered, porous limestone. It is closely associated with areas of the Ritidian soils.

Guam soils are very shallow and well drained. They are red cobbly clay loam throughout. Porous limestone dominantly is at a depth of 10 to 25 centimeters.

Of minor extent in this unit in the northern part of the survey area are deep, sandy Shioya soils along strandlines. In the southern part are deep, clayey, somewhat poorly drained Inarajan soils on bottom lands and shallow Agfayan soils over tuffaceous sandstone.

This unit is used as watershed and wildlife habitat. It is not suited to urban development or farming. The unit is severely limited by steepness of slope, areas of Rock outcrop, and the very shallow soil depth.

This unit provides important and valuable wildlife habitat. The clifflines are used as nesting sites by many species, including the endangered Marianas fruit bat and the Vanikoro swiftlet. The forest in most areas is relatively undisturbed, and it is the only remaining native forest in the survey area.

7. Pulantat

Shallow, well drained, gently sloping to steep soils; on dissected plateaus and hills

This map unit is in the central and southeastern parts of the survey area. It is characterized by dissected plateaus and rounded, steep hills with some karst topography. Closed basins and depressional areas are common. Drainageways are narrow and are intermittent in places. Slope is 3 to 60 percent. The vegetation is mainly forest.

This unit makes up about 9 percent of the survey area. It is about 80 percent Pulantat soils. The remaining 20 percent is components of minor extent.

Pulantat soils are clay and silty clay throughout. Argillaceous limestone is at a depth of 25 to 51 centimeters.

Of minor extent in this unit are 5 percent Chacha and Chacha Variant soils, 5 percent Ritidian soils, and 10 percent Sasalaguan, Inarajan, Shioya, Kagman, and Saipan soils. Chacha and Chacha Variant soils are in closed depressional areas. Ritidian soils are very shallow and are on steep slopes and escarpments. Shioya soils are sandy and are along strandlines, Inarajan soils are on bottom lands, and Sasalaguan, Kagman, and Saipan soils are on plateaus.

This unit is used for low density homesite development, recreational development, limited agriculture, watershed, and wildlife habitat.

This unit is poorly suited to agriculture. Most of the unit is too steep to farm. Most areas on plateaus are limited by shallow soil depth, but farming is feasible with careful irrigation and fertility management.

This unit is poorly suited to homesite development. The rounded hilltops and ridgetops can be used as homesites, but roads must be designed to compensate for the steep side slopes, low soil strength, and intermittent ponding in depressional areas.

The intermittently ponded depressional areas and bottom lands in this unit provide important wetland wildlife habitat. The northernmost mapped area of this unit is the watershed for Agana Swamp, which is also an important wetland site.

8. Pulantat-Kagman-Chacha

Shallow, deep, and very deep, somewhat poorly drained and well drained, nearly level to strongly sloping soils; on plateaus and hills

This map unit is in the central and southeastern parts of the survey area. It is characterized by undulating plateaus with occasional low, rounded hills and closed depressional areas. Slope is 3 to 15 percent. The vegetation in areas not cultivated is mainly grasses, forbs, and forest.

This unit makes up about 3 percent of the survey area. It is about 45 percent Pulantat soils, 30 percent Kagman soils, and 20 percent Chacha soils. The remaining 5 percent is soils of minor extent.

Pulantat soils are in convex areas and on upper side slopes. These soils are shallow and well drained. They formed in residuum derived dominantly from argillaceous limestone. The soils are clay and silty clay throughout. Argillaceous limestone is at a depth of 25 to 51 centimeters.

Kagman soils are on lower lying slopes and in nearly level areas. These soils are very deep and deep and are well drained. They formed in residuum derived dominantly from argillaceous limestone. The soils are clay throughout.

Chacha soils are in depressional areas. These soils are very deep and are somewhat poorly drained. They formed in sediment derived dominantly from argillaceous limestone and volcanic saprolite. The soils are clay throughout. Black manganese concretions commonly are in the upper part. Saprolite that has pale, elongated mottles is below a depth of 102 centimeters.

Of minor extent in this unit are Saipan soils and Urban land in the villages of Yona and Talofofo.

This unit is used for crops and as homesites.

The Pulantat soils in this unit are poorly suited to crops, and the Chacha and Kagman soils are moderately suited. Melons, beans, bananas, and other crops are

Figure 5.—Inarajan soils, in foreground, along the southern and coastal plains; these soils are used for grazing and agriculture. Agfayan soils, in background, are used as wildlife habitat and watershed.

grown. Excess water, particularly on the Chacha soils, is a problem during the rainy season. Areas of the deep and very deep Kagman and Chacha soils generally are better suited to farming than are areas of the shallow Pulantat soils, although drainage in the rainy season is better on the Pulantat soils.

If this unit is used for homesite development, the main limitations are the shallow depth of the Pulantat soils, low strength of the Kagman and Chacha soils, and wetness of the Chacha soils in the rainy season.

Broad Land Use Considerations

The soils in Guam vary widely in their potential for major land uses. Farming, grazing, urbanization, recreation, watershed, and wildlife habitat are the major land uses.

Although farming is economically and culturally important in Guam, less than 1 percent of the land is actually cultivated at any one time. Most of this land is in general soil map units 1, 3, 4, and 8. The Inarajan soils

in unit 1 are well suited to farming during the dry season only; they are subject to flooding and a high water table during the rainy season (fig. 5). The hazard of erosion, soil acidity, and wetness during the rainy season limit the soils in unit 3. The soils in unit 4 are very shallow, but several crops are widely grown with careful management. The deep soils in unit 8 are well suited to farming, but wetness during the rainy season limits field access. Most of the soils in units 2, 6, and 7 are too steep or shallow for farming, although a few small areas are suitable. Unit 5 is heavily urbanized.

About one-third of Guam is in savannah vegetation, although very little of this is actually grazed. Most of this vegetation is in unit 2, and a high percentage of this unit is too steep for grazing. The nonforested Inarajan soils in unit 1 provide excellent grazing, although animals should be removed from the field during periods of flooding and when the soils are ponded. Unit 3 is well suited to grazing, especially in areas where foxtail (*Pennesitum polystachyon*) or other introduced species are dominant. Most areas in units 4 through 8 are forested or urbanized, although isolated areas in units 4, 7, and 8 are used for grazing.

Urbanization has become a major land use on Guam. Most urban areas are in unit 5, which makes up about 14 percent of the island. Much of this area is on military installations, and it includes abandoned areas such as Northwest Field on Andersen Air Force Base. There are still areas of soils in unit 5 that could be urbanized. Unit 4 and the nearly level areas in unit 7 are well suited to urbanization, although the shallow depth to bedrock will interfere with excavation. Units 3 and 8 are moderately suited to urbanization. Low soil strength is the main limitation of the deep soils in these units. Unit 1 is poorly suited to urbanization because of flooding, seasonal soil wetness, and low soil strength. Units 2 and 6 generally are too steep or rough for urbanization.

Areas of all units have been used for recreational development. Recreational areas include small picnic areas along the beach, golf courses, and hiking trails meandering through thousands of hectares of mountains. Unit 1 is limited by flooding, wetness, and low soil strength. Unit 2 is limited by steep, unstable slopes. Units 3 and 8 are limited by low soil strength. Unit 4 and the nearly level areas of unit 7 are shallow and droughty, which could hinder excavations and limit landscaping for golf fairways. Other areas of unit 7 are limited by steepness of slope. Unit 6 is limited by steepness of slope and areas of jagged limestone Rock outcrop.

Most of the island is used as watershed and wildlife habitat, although not all areas are designated as such. Areas that are recognized as important watershed include the drainageways into Fena Lake in unit 2 and most of the northern plateau in unit 4, which recharges the northern aquifer. Areas recognized as important wildlife habitat include most of Naval Magazine and the Territorial Seashore Park in unit 2; many small wetland areas, including Agana Swamp, in unit 1; and most of the northern part of unit 6, on Andersen Air Force Base and in the Anao Conservation Area.

Unit 1, particularly the poorly drained areas, is well suited to wetland habitat. The many springs in this unit are important as sources of water. Unit 2 is well suited to wildlife habitat, particularly for openland species such as black frankolin. Limited access and steepness of slope make management difficult. Wildfire is a major management concern. Unit 3 is used for agriculture, but it also provides good habitat for openland species. Conservation plantings for wildlife are suited to this unit. Wildfire is a major management concern. Units 4, 6, and 7 are well suited to forest land wildlife species, although the shallow, droughty soils limit use of conservation plantings. Units 4 and 7 are very important to the recharge of the northern aquifer, which is the source of most of the domestic water supply for Guam. Unit 5 is suited to wildlife species that can live in residential and urbanized environments. Conservation plantings in backyards and along city streets can improve the habitat. Runoff from this unit enters the northern aquifer and should be closely monitored to prevent contamination.

Detailed Soil Map Units

The map units delineated on the detailed maps at the back of this survey represent the soils or miscellaneous areas in the survey area. The map unit descriptions in this section, along with the maps, can be used to determine the suitability and potential of a unit for specific uses. They also can be used to plan the management needed for those uses. More information on each map unit is given under "Use and Management of the Soils."

A map unit delineation on a map represents an area dominated by one or more major kinds of soil or miscellaneous areas. A map unit is identified and named according to the taxonomic classification of the dominant soils or miscellaneous areas. Within a taxonomic class there are precisely defined limits for the properties of the soils. On the landscape, however, the soils and miscellaneous areas are natural phenomena, and they have the characteristic variability of all natural phenomena. Thus, the range of some observed properties may extend beyond the limits defined for a taxonomic class. Areas of soils of a single taxonomic class rarely, if ever, can be mapped without including areas of other taxonomic classes. Consequently, every map unit is made up of the soils or miscellaneous areas for which it is named and some "included" areas that belong to other taxonomic classes.

Most included soils have properties similar to those of the dominant soil or soils in the map unit, and thus they do not affect use and management. These are called noncontrasting, or similar, inclusions. They may or may not be mentioned in the map unit description. Other included soils and miscellaneous areas, however, have properties and behavior divergent enough to affect use or to require different management. These are called contrasting, or dissimilar, inclusions. They generally are in small areas and could not be mapped separately because of the scale used. Some small areas of strongly contrasting soils or miscellaneous areas are identified by a special symbol on the maps. The included areas of contrasting soils or miscellaneous areas are mentioned in the map unit descriptions. A few included areas may not have been observed, and consequently they are not mentioned in the descriptions, especially where the pattern was so complex that it was impractical to make enough observations to identify all the soils and miscellaneous areas on the landscape.

The presence of included areas in a map unit in no way diminishes the usefulness or accuracy of the data. The objective of mapping is not to delineate pure taxonomic classes but rather to separate the landscape into segments that have similar use and management requirements. The delineation of such landscape segments on the map provides sufficient information for the development of resource plans, but if intensive use of small areas is planned, onsite investigation to precisely define and locate the soils and miscellaneous areas is needed.

An identifying symbol precedes the map unit name in the map unit descriptions. Each description includes general facts about the unit and gives the principal hazards and limitations to be considered in planning for specific uses.

Soils that have profiles that are almost alike make up a *soil series*. Except for differences in texture of the surface layer or of the underlying layers, all the soils of a series have major horizons that are similar in composition, thickness, and arrangement.

Soils of one series can differ in texture of the surface layer or of the underlying layers. They also can differ in slope, stoniness, salinity, wetness, degree of erosion, and other characteristics that affect their use. On the basis of such differences, a soil series is divided into *soil phases*. Most of the areas shown on the detailed soil maps are phases of soil series. The name of a soil phase commonly indicates a feature that affects use or management. For example, Pulantat clay, 7 to 15 percent slopes, is one of several phases in the Pulantat series.

Some map units are made up of two or more major soils or miscellaneous areas. These map units are complexes, associations, or undifferentiated groups.

A *complex* consists of two or more soils or miscellaneous areas in such an intricate pattern or in such small areas that they cannot be shown separately on the maps. The pattern and proportion of the soils or miscellaneous areas are somewhat similar in all areas. Pulantat-Kagman clays, 0 to 7 percent slopes, is an example.

An *association* is made up of two or more geographically associated soils or miscellaneous areas that are shown as one unit on the maps. Because of present or anticipated uses of the map units in the survey area, it was not considered practical or necessary

to map the soils or miscellaneous areas separately. The pattern and relative proportion of the soils or miscellaneous areas are somewhat similar. Akina-Atate association, steep, is an example.

This survey includes *miscellaneous areas*. Such areas have little or no soil material and support little or no vegetation. Badland is an example.

This survey was mapped at two levels of detail. At the most detailed level, map units are narrowly defined. This means that map unit boundaries were plotted and verified at closely spaced intervals. At the less detailed level, map units are broadly defined. Boundaries were plotted and verified at wider intervals. The soil associations were mapped at the less detailed level. The detail of mapping was selected to meet the anticipated long-term use of the survey, and the map units were designed to meet the needs for that use.

Table 1 gives the hectarage and proportionate extent of each map unit. Other tables (see "Summary of Tables") give properties of the soils and the limitations, capabilities, and potentials for many uses. The Glossary defines many of the terms used in describing the soils or miscellaneous areas.

Map Unit Descriptions

1—Agfayan clay, 15 to 30 percent slopes. This very shallow and shallow, well drained soil is on volcanic uplands. It formed in residuum derived dominantly from marine-deposited tuffaceous sandstone. Slopes are long and plane. The vegetation is mainly grasses and forbs. Some areas are forested. Elevation is sea level to 330 meters.

Typically, the surface layer is black clay 20 centimeters thick. Below this is black and yellowish brown clay 16 centimeters thick. Soft, fractured, yellowish brown tuffaceous sandstone is at a depth of 36 centimeters. Black clay is present in the fractures. Depth to soft bedrock is dominantly 10 to 38 centimeters. The soil is slightly acid to neutral.

Included in this unit are small areas of Akina soils on lower slopes and soils that are 50 to 100 centimeters deep to soft bedrock. Also included are small areas of Rock outcrop, mostly on shoulders and ridges. Included areas make up about 15 percent of the total hectarage.

Permeability of this Agfayan soil is moderately slow. Available water capacity is very low. Effective rooting depth is 10 to 38 centimeters. Roots penetrate the soft bedrock along fractures in some areas. Runoff is rapid, and the hazard of water erosion is severe.

This unit is used as wildlife habitat and watershed. It can be used for grazing, recreation, subsistence farming, and homesite development. The unit is not suited to commercial farming.

The use of this unit as wildlife habitat and watershed can be enhanced by protecting the unit from wildfires and by planting adapted trees. Establishing firebreaks and restricting public access can help to prevent wildfires. Prescribed burning of adjacent cropland should be closely supervised. Forest cover improves the watershed by reducing surface runoff and erosion. It also provides valuable cover for wildlife.

This unit is moderately suited to grazing. The main limitations are gully erosion caused by continuous grazing and the very low available water capacity. The quality of tropical forage is extremely low if it is allowed to mature. Livestock rotation improves the quality of forage and helps to prevent erosion caused by overstocking and trailing. The quality of forage can be improved by introducing adapted grasses and legumes. Yield can be increased by fertilizing. Practices such as salting, constructing livestock watering facilities, fencing, mowing or dragging, and protecting the unit from fire can be used to enhance the carrying capacity of the soil and to prevent erosion.

This unit is poorly suited to subsistence farming. The main limitations are the depth to impermeable bedrock, the hazard of erosion, and the lack of water during the dry season. Fruit trees and other deep-rooted crops are not suited to this unit. Clean cultivation should be avoided. Weeds can be controlled by mulching and mowing. Compost can be applied to improve soil fertility. During the dry season, irrigation is needed for shallow-rooted vegetables.

This unit is poorly suited to homesite development. The main limitations are slope and the depth to bedrock. Slopes are too steep for conventional construction techniques. Preserving the existing plant cover during construction helps to control erosion. Topsoil can be stockpiled and used to reclaim areas disturbed during construction. Revegetating disturbed areas around construction sites as soon as possible helps to control soil erosion. Excavation is difficult because of the depth to bedrock. The cuts needed to provide level building sites will expose bedrock.

Septic tank absorption fields will not function properly because of the depth to bedrock and steepness of slope. Effluent from septic tank absorption fields can surface in downslope areas and thus create a hazard to health.

The main limitations for recreational development are slope, low soil strength, and the hazard of erosion. Plant cover can be maintained by limiting traffic. Paths and trails should extend across the slope and along ridgelines.

This map unit is in capability subclass VIe.

2—Agfayan clay, 30 to 60 percent slopes. This very shallow and shallow, well drained soil is on volcanic uplands. It formed in residuum derived dominantly from marine-deposited tuffaceous sandstone. Slopes are long and plane. The vegetation is mainly grasses and forbs. Some areas are forested. Elevation is sea level to 330 meters.

Typically, the surface layer is black clay 20 centimeters thick. Below this is black and yellowish brown clay 16 centimeters thick. Soft, fractured, yellowish brown tuffaceous sandstone is at a depth of 36 centimeters. Black clay is present in the fractures. Depth to soft bedrock is dominantly 10 to 38 centimeters. The soil is slightly acid to neutral.

Included in this unit are small areas of Akina soils on lower slopes and soils that are 38 to 100 centimeters deep to soft bedrock. Also included are small areas of Rock outcrop, mostly on shoulders and ridges. Included areas make up about 15 percent of the hectarage.

Permeability of this Agfayan soil is moderately slow. Available water capacity is very low. Effective rooting depth is 10 to 38 centimeters. Roots may penetrate the soft bedrock along fractures. Runoff is rapid, and the hazard of water erosion is severe.

This unit is used as wildlife habitat and watershed. It can be used for recreation. The unit is not suited to grazing, subsistence or commercial farming, or homesite development.

The use of this unit as wildlife habitat and watershed can be enhanced by protecting the unit from wildfires and by planting adapted trees. Establishing firebreaks and restricting public access can help to prevent wildfires. Prescribed burning of adjacent cropland should be closely supervised. Forest cover improves the watershed by reducing surface runoff and erosion. It also provides valuable cover for wildlife.

Slope limits the recreational use of this unit mainly to a few paths and trails, which should extend across the slope and along ridgelines.

This map unit is in capability subclass VIIe.

3—Agfayan-Rock outcrop complex, 7 to 15 percent slopes. This map unit is on volcanic uplands. Slopes generally are short and undulating but are broken by an occasional short, steep dropoff. Areas are narrow and irregular in shape. The vegetation on the Agfayan soil is mainly grasses and forbs. The areas of Rock outcrop are barren. Elevation is 30 to 100 meters.

This unit is 60 percent Agfayan clay and 20 percent Rock outcrop. The Agfayan soil is on side slopes, and Rock outcrop is on ridges, shoulders, and upper side slopes. The components of this unit are so intricately intermingled that it was not practical to map them separately.

The Agfayan soil is very shallow and shallow and is well drained. It formed in residuum derived dominantly from marine-deposited tuffaceous sandstone. Typically, the surface layer is black clay 20 centimeters thick. Below this is black and yellowish brown clay 16 centimeters thick. Soft, fractured, yellowish brown tuffaceous sandstone is at a depth of 36 centimeters. Black clay is present in the fractures. Depth to soft bedrock is dominantly 10 to 38 centimeters. The soil is slightly acid to neutral.

Permeability of this Agfayan soil is moderately slow. Available water capacity is very low. Effective rooting depth is 10 to 38 centimeters. Roots may penetrate the soft bedrock along fractures. Runoff is medium, and the hazard of water erosion is moderate.

Rock outcrop is exposures of hard to very hard, yellowish brown, marine-deposited tuffaceous sandstone. The surface can be chipped with a spade. A pickax will penetrate the rock, but digging by hand is very difficult. Cracks and seams are common. The surface generally is smooth; however, in a few areas in central Guam the rock protrudes vertically from the ridges and side slopes. The areas of Rock outcrop support little if any vegetation.

Water penetrates the areas of Rock outcrop only along cracks and seams. Runoff is very rapid, which may result in erosion in downslope areas. The Rock outcrop is moderately resistant to erosion.

Included in this unit are small areas of moderately deep to deep, somewhat poorly drained soils along drainageways and in low spots. Also included are small areas of soils that are 38 to 100 centimeters deep to bedrock, Sasalaguan soils, and Akina soils. Most of these areas are on intermediate to lower slopes. A few areas of Badland are associated with areas of the Akina soil. Included areas make up about 20 percent of the total hectarage.

This unit is used mainly as wildlife habitat and watershed. It can be used for grazing, subsistence farming, and homesite and recreational development. It is not suited to commercial farming.

The use of this unit as wildlife habitat and watershed can be enhanced by protecting the unit from wildfires and by planting adapted trees. Establishing firebreaks and restricting public access can help to prevent wildfires. Prescribed burning of adjacent cropland should be closely supervised. Forest cover improves the watershed by reducing surface runoff and erosion. It also provides valuable cover for wildlife.

This unit is moderately suited to grazing. The main limitations are gully erosion caused by continuous grazing and the very low available water capacity. The areas of Rock outcrop are not suitable for grazing. The quality of tropical forage is extremely low if it is allowed to mature. Livestock rotation improves the quality of forage and helps to prevent erosion caused by overstocking and trailing. The quality of forage can be improved by introducing adapted grasses and legumes. Yield can be increased by fertilizing. Practices such as salting, constructing livestock watering facilities, fencing, mowing or dragging, and protecting the unit from fire can be used to enhance the carrying capacity of the soil and to prevent erosion.

This unit is poorly suited to subsistence farming. The main limitations are the depth to impermeable bedrock, the areas of Rock outcrop, the hazard of erosion, and lack of water during the dry season. Fruit trees and other

deep-rooted crops are not suited to this unit. All tillage should be across the slope. Clean cultivation should be avoided. Weeds can be controlled by mulching and mowing. Compost can be applied to improve soil fertility. During the dry season, irrigation is needed for shallow-rooted vegetables.

This unit is poorly suited to homesite development. The main limitations are slope and depth to bedrock. Preserving the existing plant cover during construction helps to control erosion. Topsoil can be stockpiled and used to reclaim areas disturbed during construction. Revegetating disturbed areas around construction sites as soon as possible helps to control soil erosion. Excavation is difficult because of the depth to bedrock. The cuts needed to provide level building sites will expose bedrock.

Septic tank absorption fields will not function properly because of the depth to bedrock and slope. Effluent from septic tank absorption fields can surface in downslope areas and create a hazard to health.

The main limitations for recreational development are the hazard of erosion and low strength of the Agfayan soil. Plant cover can be maintained by limiting traffic.

The Agfayan soil is in capability subclass IVs. Rock outcrop is in capability subclass VIIIs.

4—Agfayan-Rock outcrop complex, 15 to 30 percent slopes. This map unit is on volcanic uplands. Slopes are long and plane. The vegetation on the Agfayan soil is mainly grasses and forbs. The areas of Rock outcrop are barren. Elevation is 10 to 300 meters.

This unit is 55 percent Agfayan clay and 25 percent Rock outcrop. The Agfayan soil is on side slopes, and the areas of Rock outcrop are on ridgelines, shoulders, and upper side slopes. The components of this unit are so intricately intermingled that it was not practical to map them separately.

The Agfayan soil is very shallow and shallow and is well drained. It formed in residuum derived dominantly from marine-deposited tuffaceous sandstone. Typically, the surface layer is black clay 20 centimeters thick. Below this is black and yellowish brown clay 16 centimeters thick. Soft, fractured, yellowish brown tuffaceous sandstone is at a depth of 36 centimeters. Black clay is present in the fractures. Depth to soft bedrock is dominantly 10 to 38 centimeters. The soil is slightly acid to neutral.

Permeability of this Agfayan soil is moderately slow. Available water capacity is very low. Effective rooting depth is 10 to 38 centimeters. Roots may penetrate the soft bedrock along fractures. Runoff is rapid, and the hazard of water erosion is severe.

Rock outcrop is exposures of hard to very hard, yellowish brown, marine-deposited tuffaceous sandstone. The surface can be chipped with a spade. A pickax will penetrate the rock, but digging by hand is very difficult. Cracks and seams are common. The surface generally is smooth; however, in a few areas in central Guam the rock protrudes vertically from the ridges and side slopes. The areas of Rock outcrop support little if any vegetation.

Water penetrates the areas of Rock outcrop only along cracks and seams. Runoff is very rapid, which may result in erosion in downslope areas. The Rock outcrop is moderately resistant to erosion.

Included in this unit are small areas of moderately deep to deep, somewhat poorly drained soils along draws and in swales. Also included are small areas of soils that are 38 to 100 centimeters deep to bedrock, Sasalaguan soils, and Akina soils. Most of these areas are on intermediate to lower slopes. A few areas of Badland are associated with areas of the Akina soil. Included areas make up about 20 percent of the total hectarage.

This unit is used mainly as wildlife habitat and watershed. It can be used for grazing, recreation, subsistence farming and homesite development. It is not suited to commercial farming.

The use of this unit as wildlife habitat and watershed can be enhanced by protecting the unit from wildfires and by planting adapted trees. Establishing firebreaks and restricting public access can help to prevent wildfires. Prescribed burning of adjacent cropland should be closely supervised. Forest cover improves the watershed by reducing erosion and surface runoff. It also provides valuable cover for wildlife.

This unit is poorly suited to grazing. The main limitations are gully erosion caused by continuous grazing and the very low available water capacity. The areas of Rock outcrop are not suited to grazing. The quality of tropical forage is extremely low if it is allowed to mature. Livestock rotation improves the quality of forage and helps to prevent erosion caused by overstocking and trailing. The quality of forage can be improved by introducing adapted grasses and legumes. Yield can be increased by fertilizing. Practices such as salting, constructing livestock watering facilities, fencing, mowing or dragging, and protecting the unit from fire can be used to enhance the carrying capacity of the soil and to prevent erosion.

This unit is poorly suited to subsistence farming. The main limitations are the depth to impermeable bedrock, the hazard of erosion, the areas of Rock outcrop, and lack of water during the dry season. Fruit trees and other deep-rooted crops are not suited to this unit. All tillage should be across the slope. Clean cultivation should be avoided. Weeds can be controlled by mulching and mowing. Compost can be applied to improve soil fertility. During the dry season, irrigation is needed for shallow-rooted vegetables.

This unit is poorly suited to homesite development. The main limitations are slope and depth to bedrock. Slopes are too steep for conventional construction techniques. Preserving the existing plant cover during

construction helps to control erosion. Topsoil can be stockpiled and used to reclaim areas disturbed during construction. Revegetating disturbed areas around construction sites as soon as possible helps to control soil erosion. Excavation is difficult because of the depth to bedrock. The cuts needed to provide level building sites will expose bedrock.

Septic tank absorption fields will not function properly because of the depth to bedrock and slope. Effluent from septic tank absorption fields can surface in downslope areas and thus create a hazard to health.

The main limitations for recreational development are slope, the hazard of erosion, and low strength of the Agfayan soil. Plant cover can be maintained by limiting traffic. Paths and trails should extend across the slope and along ridgelines.

The Agfayan soil is in capability subclass VIe. Rock outcrop is in capability subclass VIIIs.

5—Agfayan-Rock outcrop complex, 30 to 60 percent slopes. This map unit is on volcanic uplands. Slopes are long and dissected. The vegetation on the Agfayan soil is mainly grasses and forbs. The areas of Rock outcrop are barren. Elevation is 10 to 300 meters.

This unit is 65 percent Agfayan clay and 25 percent Rock outcrop. The Agfayan soil is on side slopes, and the areas of Rock outcrop are on ridgelines, shoulder slopes, and upper side slopes. The components of this unit are so intricately intermingled that it was not practical to map them separately.

The Agfayan soil is very shallow and shallow and is well drained. It formed in residuum derived dominantly from marine-deposited tuffaceous sandstone. Typically, the surface layer is black clay 20 centimeters thick. Below this is black and yellowish brown clay 16 centimeters thick. Soft, fractured, yellowish brown tuffaceous sandstone is at a depth of 36 centimeters. Black clay is present in the fractures. Depth to soft bedrock is dominantly 10 to 38 centimeters. The soil is slightly acid to neutral.

Permeability of this Agfayan soil is moderately slow. Available water capacity is very low. Effective rooting depth is 10 to 38 centimeters. Roots may penetrate the soft bedrock along fractures. Runoff is rapid, and the hazard of water erosion is severe.

Rock outcrop is exposures of hard to very hard, yellowish brown, marine-deposited tuffaceous sandstone. The surface can be chipped with a spade. A pickax will penetrate the rock, but digging by hand is very difficult. Cracks and seams are common. The surface generally is smooth; however, in a few areas in central Guam the rock protrudes vertically from the ridges and side slopes. The areas of Rock outcrop support little if any vegetation.

Water penetrates the areas of Rock outcrop only along cracks and seams. Runoff is very rapid, which may result in erosion in downslope areas. The Rock outcrop is moderately resistant to erosion.

Included in this unit are small areas of soils that are 38 to 100 centimeters deep to bedrock and Akina soils, mostly on intermediate to lower slopes. Also included are small areas of Badland and moderately deep to deep, somewhat poorly drained soils along draws and swales. Included areas make up about 10 percent of the total hectarage.

This unit is used as wildlife habitat and watershed. It can be used for recreation. It is not suited to grazing, subsistence or commercial farming, or homesite development.

The use of this unit as wildlife habitat and watershed can be enhanced by protecting the unit from wildfires and by planting adapted trees. Establishing firebreaks and restricting public access can help to prevent wildfires. Prescribed burning of adjacent cropland should be closely supervised. Forest cover improves the watershed by reducing erosion and surface runoff. It also provides valuable cover for wildlife.

Slope limits the recreational use of this unit mainly to a few paths and trails, which should extend across the slope and along ridgelines.

The Agfayan soil is in capability subclass VIIe, and the Rock outcrop is in capability subclass VIIIs.

6—Agfayan-Akina association, extremely steep. This map unit is on mountainous, volcanic uplands in the interior, high elevation areas of southern Guam. Slope is 40 to 99 percent. Slopes are highly dissected and irregular. The vegetation is mainly grasses on the exposed ridgelines and upper slopes and forest on the lower slopes. Elevation is 150 to 220 meters.

This unit is 60 percent Agfayan clay and 30 percent Akina silty clay. The components are not present in a predictable pattern.

The Agfayan soil is very shallow and shallow and is well drained. It formed in residuum derived dominantly from marine-deposited tuffaceous sandstone. Typically, the surface layer is black clay about 20 centimeters thick. Below this is black and yellowish brown clay 16 centimeters thick. Soft, fractured, yellowish brown tuffaceous sandstone is at a depth of 36 centimeters. Black clay is present in the fractures. Depth to soft bedrock is dominantly 10 to 38 centimeters. The soil is slightly acid to neutral.

Permeability of this Agfayan soil is moderately slow. Available water capacity is very low. Effective rooting depth is 10 to 38 centimeters. Roots may penetrate the soft bedrock along fractures. Runoff is rapid, and the hazard of water erosion is severe.

The Akina soil is very deep and well drained. It formed in colluvium and residuum derived dominantly from tuff and tuff breccia. Typically, the surface layer is dark reddish brown silty clay about 10 centimeters thick. The subsoil is dark red clay about 51 centimeters thick.

Mixed red and white silty clay saprolite is at a depth of 61 centimeters. Depth to saprolite ranges from 51 to 102 centimeters. The soil is very strongly acid to strongly acid throughout.

Permeability of this Akina soil is moderately slow. Available water capacity is moderate. Effective rooting depth is 150 centimeters or more. Runoff is rapid, and the hazard of water erosion is severe.

Included in this unit are small areas of soils that are deep to soft bedrock, soils on ridgelines and in drainageways that have slopes of less than 40 percent, and soils in stream channels that are incised to bedrock. Also included are small areas of Ylig soils in seep areas and areas of vertical rock faces. Included areas make up about 10 percent of the total hectarage.

This unit is used as watershed and wildlife habitat. It can be used for recreational development. It is not suited to commercial or subsistence farming, grazing, or homesite development. The main limitations are the steepness of slope and the hazard of erosion.

The use of this unit as wildlife habitat and watershed can be enhanced by maintaining the forest cover and savannah vegetation and protecting it from wildfires. Establishing firebreaks and restricting public access can help to prevent wildfires. Prescribed burning of adjacent cropland should be closely supervised.

Slope limits the recreational use of this unit mainly to a few paths and trails, which should extend across the slope and along ridgelines.

This map unit is capability subclass VIIe.

7—Agfayan-Akina-Rock outcrop association, extremely steep. This map unit is on mountainous, volcanic uplands in the interior, high elevation areas of southern Guam. Slope is 40 to 99 percent. Slopes are highly dissected and irregular. The vegetation is mainly grasses on the exposed ridgelines and upper slopes and forest on the lower slopes. Elevation is sea level to 330 meters.

This unit is 50 percent Agfayan clay, 25 percent Akina silty clay, and 20 percent Rock outcrop. The areas of Rock outcrop are on ridgelines, shoulder slopes, and nearly vertical slopes. The components are not in a predictable pattern.

The Agfayan soil is very shallow and shallow and is well drained. It formed in residuum derived dominantly from marine-deposited tuffaceous sandstone. Typically, the surface layer is black clay about 20 centimeters thick. Below this is black and yellowish brown clay 16 centimeters thick. Soft, fractured, yellowish brown tuffaceous sandstone is at a depth of 36 centimeters. Black clay is present in the fractures. Depth to soft bedrock is dominantly 10 to 38 centimeters. The soil is slightly acid to neutral.

Permeability of this Agfayan soil is moderately slow. Available water capacity is very low. Effective rooting depth is 10 to 38 centimeters. Roots may penetrate the soft bedrock along fractures. Runoff is rapid, and the hazard of water erosion is severe.

The Akina soil is very deep and well drained. It formed in colluvium and residuum derived dominantly from tuff and tuff breccia. Typically, the surface layer is dark reddish brown silty clay about 10 centimeters thick. The subsoil is dark red clay about 51 centimeters thick. Mixed red and white silty clay saprolite is at a depth of 61 centimeters. Depth to saprolite ranges from 51 to 102 centimeters. The soil is very strongly acid to strongly acid.

Permeability of this Akina soil is moderately slow. Available water capacity is moderate. Effective rooting depth is 150 centimeters or more. Runoff is rapid, and the hazard of water erosion is severe.

Rock outcrop is exposures of hard to very hard, yellowish brown, marine-deposited tuffaceous sandstone. The surface can be chipped with a spade. A pickax will penetrate the rock, but digging by hand is very difficult. Cracks and seams are common. The surface generally is smooth; however, in some areas the rock protrudes vertically from ridges and side slopes. The areas of Rock outcrop support little if any vegetation.

Water penetrates the Rock outcrop only along cracks and seams. Runoff is very rapid, which may result in erosion in downslope areas. The Rock outcrop is moderately resistant to erosion.

Included in this unit are small areas of soils that are deep to soft bedrock, soils on ridgelines and in drainageways that have slopes of less than 40 percent, and soils in stream channels that are incised to bedrock. Also included are small areas of Ylig soils in seep areas. Included areas make up about 5 percent of the total hectarage.

This unit is used as watershed and wildlife habitat. It can be used for recreational development. It is not suited to commercial or subsistence farming, grazing, or homesite development. The main limitations are the steepness of slope and the hazard of erosion.

The use of this unit as wildlife habitat and watershed can be enhanced by maintaining the forest cover and savannah vegetation and protecting it from wildfires. Establishing firebreaks and restricting public access can help to prevent wildfires. Prescribed burning of adjacent cropland should be closely supervised.

Slope limits the recreational use of this unit mainly to a few paths and trails, which should extend across the slope and along ridgelines.

The Agfayan and Akina soils are in capability subclass VIIe. The Rock outcrop is in capability subclass VIIIs.

8—Akina silty clay, 3 to 7 percent slopes. This very deep, well drained soil is on volcanic uplands. It formed in residuum derived dominantly from tuff and tuff breccia. Slopes are long and plane. The vegetation is mainly grasses and forbs. Some areas are forested. Elevation is 10 to 330 meters.

Typically, the surface layer is dark reddish brown silty clay about 10 centimeters thick. The subsoil is dark red clay about 51 centimeters thick. Mixed red and white silty clay saprolite is at a depth of 61 centimeters. The soil is very strongly acid to strongly acid throughout.

Included in this unit are small areas of Agfayan and Atate soils and Togcha soils in downslope areas. Also included are small areas of soils that have an eroded surface layer, Badland that has been deeply gullied to expose saprolite, soils that are moderately deep to very firm sandstone, soils that are nearly level, and soils that have short, moderately steep slopes. Included areas make up about 10 percent of the total hectarage.

Permeability of this Akina soil is moderately slow. Available water capacity is moderate. Effective rooting depth is 150 centimeters or more. Runoff is medium, and the hazard of water erosion is moderate.

This unit is used mainly as wildlife habitat and watershed. It is also used for subsistence and commercial farming. The unit can be used for grazing and homesite and recreational development.

The use of this unit as wildlife habitat and watershed can be enhanced by protecting the unit from wildfires and by planting adapted trees in areas of savannah vegetation. Establishing firebreaks and restricting public access can help to prevent wildfires. Prescribed burning of adjacent cropland should be closely supervised. Forest cover improves the watershed by reducing surface runoff and erosion. It also provides valuable cover for wildlife.

This unit is moderately suited to subsistence farming. The main limitations are low soil fertility, soil acidity, and lack of water during the dry season. Compost can be applied to improve soil fertility. Crushed coral limestone can be mixed into the soil to provide calcium and to reduce soil acidity. During the dry season, irrigation is needed for shallow-rooted vegetables. Growth and production of banana, papaya, and other fruit trees can be increased by irrigation.

This unit is moderately suited to commercial farming. Crops that can be grown include watermelon, chinese and head cabbage, and fruit trees that are adapted to clayey, acidic soils. The main limitations are the hazard of erosion, low soil fertility, soil acidity, and lack of water during the dry season. Erosion can be minimized by installing diversions or terraces and by planting cover crops. Crops respond to fertilizer and lime. The organic matter content can be maintained by rotating crops and by plowing under cover crops and all crop residue. During the dry season, irrigation is required for maximum production of vegetable crops. Drip irrigation is suited to this unit. Windbreaks are needed for production of crops.

This unit is well suited to grazing. The quality of tropical forage is extremely low if it is allowed to mature. Livestock rotation improves the quality of forage and helps to prevent erosion caused by overstocking and trailing. The quality of forage can be improved by introducing adapted grasses and legumes. Yield can be increased by fertilizing and liming. Practices such as salting, constructing livestock watering facilities, fencing, mowing or dragging, and protecting the unit from fire can be used to enhance the carrying capacity of the soil and to prevent erosion.

This unit is moderately suited to homesite development. The main limitation for roads is low soil strength. The load bearing capacity of the soil can be improved by spreading gravel fill before constructing buildings or roads. Preserving the existing plant cover during construction helps to control erosion. Topsoil can be stockpiled and used to reclaim areas disturbed during construction. Revegetating disturbed areas around construction sites as soon as possible helps to control soil erosion.

If this unit is used for septic tank absorption fields, the limitation of moderately slow permeability can be overcome by increasing the size of the absorption field. If the density of housing is moderate to high, community sewage systems are needed to prevent contamination of water supplies as a result of seepage from onsite sewage disposal systems.

The main limitation of this unit for recreational development is the low soil strength. The load bearing capacity of the soil can be improved by spreading gravel fill before constructing roads, buildings, and trails. Plant cover can be maintained by limiting traffic.

This map unit is in capability subclass IIe.

9—Akina silty clay, 7 to 15 percent slopes. This very deep, well drained soil is on volcanic uplands. It formed in residuum derived dominantly from tuff and tuff breccia. Slopes are long and plane. The vegetation is mainly grasses and forbs. Some areas are forested. Elevation is 10 to 330 meters.

Typically, the surface layer is dark reddish brown silty clay about 10 centimeters thick. The subsoil is dark red clay about 51 centimeters thick. Mixed dark red and white silty clay saprolite is at a depth of 61 centimeters. Depth to saprolite ranges from 51 to 102 centimeters. The soil is very strongly acid to strongly acid throughout.

Included in this unit are small areas of Agfayan and Atate soils and Togcha soils in downslope areas. Also included are small areas of soils that have an eroded surface layer, Badland that has been deeply gullied to expose saprolite, soils that are moderately deep to very firm tuffaceous sandstone, soils that are nearly level and are on ridgelines and toe slopes, and soils that have short, moderately steep slopes. The Ordot Dump is also included in this unit. Included areas make up about 10 percent of the total hectarage.

Permeability of this Akina soil is moderately slow. Available water capacity is moderate. Effective rooting depth is 150 centimeters or more. Runoff is medium, and the hazard of water erosion is moderate.

This unit is used mainly as wildlife habitat and watershed. It is also used for commercial and subsistence farming. It can be used for grazing and homesite and recreational development.

The use of this unit as wildlife habitat and watershed can be enhanced by protecting the unit from wildfires and by planting adapted trees. Establishing firebreaks and restricting public access can help to prevent wildfires. Prescribed burning on adjacent cropland should be closely supervised. Forest cover improves the watershed by reducing surface runoff and erosion. It also provides valuable cover for wildlife.

This unit is moderately suited to subsistence farming. The main limitations are low soil fertility, soil acidity, the hazard of erosion, and lack of water during the dry season. Compost can be applied to improve soil fertility. Crushed coral limestone can be mixed into the soil to provide calcium and to reduce soil acidity. Clean cultivation should be avoided. Weeds can be controlled by mulching and mowing. During the dry season, irrigation is needed for shallow-rooted vegetables. Growth and production of banana, papaya, and other fruit trees can be increased by irrigating during the dry season.

This unit is moderately suited to commercial farming. Crops that can be grown include watermelons, head and Chinese cabbages, and fruit trees that are adapted to clayey, acidic soils. The main limitations are the hazard of erosion, low soil fertility, soil acidity, and lack of water during the dry season. All tillage should be across the slope. Erosion can be reduced by avoiding clean cultivation, by installing diversions, terraces, or grassed waterways, and by planting cover crops. Crops respond to fertilizer and lime. The organic matter content can be maintained by rotating crops and by plowing under cover crops and all crop residue. During the dry season, irrigation is required for maximum production of row crops. Drip irrigation is suited to the soil in this unit. Windbreaks are needed for the production of crops.

This unit is well suited to grazing. The quality of tropical forage is extremely low if it is allowed to mature. Livestock rotation improves the quality of forage and helps to prevent erosion caused by overstocking and trailing. The quality of forage can be improved by introducing adapted grasses and legumes. Yield can be increased by fertilizing and liming. Practices such as salting, constructing livestock watering facilities, fencing, mowing or dragging, and protecting the unit from fire can be used to enhance the carrying capacity of the soil and to prevent erosion.

This unit is moderately suited to homesite development. The main limitation is slope. Preserving the existing plant cover during construction and revegetating disturbed areas around construction sites as soon as possible help to control soil erosion. Topsoil can be stockpiled and used to reclaim areas disturbed during construction. The main limitation for roads is low soil strength. The load bearing capacity of the soil can be improved by spreading gravel fill before constructing buildings and roads.

If this unit is used for septic tank absorption fields, the limitation of moderately slow permeability can be overcome by increasing the size of the absorption field. Slope is a concern in installing septic tank absorption fields. Absorption lines should be installed on the contour. If the density of housing is moderate to high, community sewage systems are needed to prevent contamination of local streams as a result of seepage from onsite sewage disposal systems.

The main limitation of this unit for recreational development is the hazard of erosion and slope. Plant cover can be maintained by limiting traffic. Playgrounds, ball fields, and other recreation areas that require level slopes are difficult to establish on this unit.

This map unit is in capability subclass IIIe.

10—Akina silty clay, 15 to 30 percent slopes. This very deep, well drained soil is on volcanic uplands. It formed in residuum derived dominantly from tuff and tuff breccia. Slopes are long and plane. The vegetation is mainly grasses and forbs. Some areas are forested. Elevation is 10 to 330 meters.

Typically, the surface layer is dark reddish brown silty clay about 10 centimeters thick. The subsoil is dark red clay about 51 centimeters thick. Mixed dark red and white silty clay saprolite is at a depth of 61 centimeters. Depth to saprolite ranges from 51 to 102 centimeters. The soil is very strongly acid to strongly acid throughout.

Included in this unit are small areas of Agfayan and Atate soils. Also included are small areas of soils that have an eroded surface layer, Badland consisting of grassland that has been deeply gullied to expose the substratum, soils that are moderately deep to very firm tuffaceous sandstone, soils that are gently sloping and are on ridgelines and toe slopes, and soils that have short, steep slopes. Included areas make up about 10 percent of the total hectarage.

Permeability of this Akina soil is moderately slow. Available water capacity is moderate. Effective rooting depth is 150 centimeters or more. Runoff is rapid, and the hazard of water erosion is severe.

This unit is used as wildlife habitat and watershed. It can be used for grazing, recreation, subsistence farming, and homesite development. The unit is not suited to commercial farming.

The use of this unit as wildlife habitat and watershed can be enhanced by protecting the unit from wildfires and by planting adapted trees. Establishing firebreaks and restricting public access can help to prevent wildfires. Prescribed burning of adjacent cropland should be closely supervised. Forest cover improves the watershed by reducing surface runoff and erosion. It also provides valuable cover for wildlife.

This unit is moderately suited to grazing. The main limitations are gully erosion caused by continuous grazing and the moderate available water capacity. The quality of tropical forage is extremely low if it is allowed to mature. Livestock rotation improves the quality of forage and helps to prevent erosion caused by overstocking and trailing. The quality of forage can be improved by introducing adapted grasses and legumes. Yield can be increased by fertilizing and liming. Practices such as salting, constructing livestock watering facilities, fencing, mowing or dragging, and protecting the unit from fire can be used to enhance the carrying capacity of the soil and to prevent erosion.

This unit is poorly suited to subsistence farming. The main limitations are the hazard of erosion, low soil fertility, soil acidity, and lack of water during the dry season. Clean cultivation should be avoided. Weeds can be controlled by mulching and mowing. Compost can be applied to improve soil fertility. Crushed coral limestone can be mixed into the soil to provide calcium and to reduce soil acidity. During the dry season, irrigation is needed for shallow-rooted vegetables. Growth and production of banana, papaya, and other fruit trees can be increased by irrigating during the dry season.

This unit is poorly suited to homesite development. The main limitation is slope. Slopes are too steep for conventional construction techniques. Only isolated ridgelines and hilltops can be used as construction sites. Preserving the existing plant cover during construction helps to control erosion. Topsoil can be stockpiled and used to reclaim areas disturbed during construction. Revegetating disturbed areas around construction sites as soon as possible helps to control soil erosion. If the unit is used for roads, the main limitation is low soil strength. The load bearing capacity of the soil in this unit can be improved by spreading gravel fill before constructing buildings and roads.

If this unit is used for septic tank absorption fields, the main limitations are slope and the moderately slow permeability. The limitation of moderately slow permeability can be overcome by increasing the size of the absorption field. Absorption lines should be installed on the contour. Specialized designs are needed to overcome the limitation of slope.

Slope limits the recreational use of this unit mainly to a few paths and trails, which should extend across the slope. Erosion and sedimentation can be controlled and the beauty of the area enhanced by maintaining adequate plant cover. Plant cover can be maintained by limiting traffic.

This map unit is in capability subclass VIe.

11—Akina silty clay, 30 to 60 percent slopes. This very deep, well drained soil is on volcanic uplands. It formed in residuum derived dominantly from tuff and tuff breccia. Slopes are long and plane. The vegetation is mainly grasses and forbs. Some areas are forested. Elevation is 10 to 330 meters.

Typically, the surface layer is dark reddish brown silty clay about 10 centimeters thick. The subsoil is dark red clay about 51 centimeters thick. Mixed dark red and white silty clay saprolite is at a depth of 61 centimeters. Depth to saprolite ranges from 51 to 102 centimeters. The soil is very strongly acid to strongly acid throughout.

Included in this unit are small areas of Agfayan and Atate soils and soils that have a gravelly and cobbly surface layer. Also included are small areas of soils that have an eroded surface layer, Badland that consists of areas that have been deeply gullied to expose the substratum, soils that are moderately deep to very firm tuffaceous sandstone, and soils that are moderately steep and are on ridgelines and benches. Included areas make up about 10 percent of the total hectarage.

Permeability of this Akina soil is moderately slow. Available water capacity is moderate. Effective rooting depth is 150 centimeters or more. Runoff is rapid, and the hazard of water erosion is very severe.

This unit is used as wildlife habitat and watershed. It can be used for recreation. The unit is not suited to grazing, subsistence or commercial farming, or homesite development.

The use of this unit as wildlife habitat and watershed can be enhanced by protecting the unit from wildfires and by planting adapted trees in the areas of savannah vegetation. Establishing firebreaks and restricting public access can help to prevent wildfires. Prescribed burning of adjacent cropland should be closely supervised. Forest cover improves the watershed by reducing surface runoff and erosion. It also provides valuable cover for wildlife.

Slope limits the recreational use of this unit mainly to a few paths and trails, which should extend across the slope and along ridgelines.

This map unit is in capability subclass VIIe.

12—Akina-Agfayan association, steep. This map unit is on mountainous volcanic uplands in the interior, high elevation areas of southern Guam. Slope is 30 to 60 percent. Slopes are dissected and irregular. The vegetation is mainly grasses with some forest on protected ravine bottoms. Elevation is 30 to 330 meters.

This unit is 50 percent Akina silty clay and 30 percent Agfayan clay. The components are not in a predictable pattern.

The Akina soil is very deep and well drained. It formed in residuum derived dominantly from tuff and tuff breccia. Typically, the surface layer is dark reddish brown silty clay about 10 centimeters thick. The subsoil is dark red clay about 51 centimeters thick. Mixed dark red and white silty clay saprolite is at a depth of 61 centimeters. Depth to saprolite ranges from 51 to 102 centimeters. The soil is very strongly acid to strongly acid throughout.

Permeability of this Akina soil is moderately slow. Available water capacity is moderate. Effective rooting depth is 150 centimeters or more. Runoff is rapid, and the hazard of water erosion is severe.

The Agfayan soil is very shallow and well drained. It formed in residuum derived dominantly from marine-deposited tuffaceous sandstone. Typically, the surface layer is black clay about 20 centimeters thick. Below this is black and yellowish brown clay 16 centimeters thick. Soft, fractured, yellowish brown tuffaceous sandstone is at a depth of 36 centimeters. Black clay is present in the fractures. Depth to soft bedrock is dominantly 10 to 38 centimeters. The soil is slightly acid to neutral.

Permeability of this Agfayan soil is moderately slow. Available water capacity is very low. Effective rooting depth is 10 to 38 centimeters. Roots may penetrate the soft bedrock along fractures. Runoff is rapid, and the hazard of water erosion is severe.

Included in this unit are 10 percent Badland and 10 percent small areas of Rock outcrop on ridgelines and knobs, Togcha soils on lower benches and slopes, soils that are moderately deep to soft bedrock, and soils that have extremely steep slopes and are along ravines and gently sloping narrow ridgelines and benches. Included areas make up about 20 percent of the total hectarage.

This unit is used as watershed and wildlife habitat. It can be used for recreational development. It is not suited to commercial or subsistence farming, grazing, or homesite development. The main limitations are steepness of slope and the hazard of erosion.

The use of this unit as wildlife habitat and watershed can be enhanced by protecting the unit from wildfires and by planting adapted trees. Establishing firebreaks and restricting public access can help to prevent wildfires. Prescribed burning of adjacent cropland should be closely supervised. Forest cover improves the watershed by reducing surface runoff and erosion. It also provides valuable cover for wildlife.

Slope limits the recreational use of this unit mainly to a few paths and trails, which should extend across the slope and along ridgelines.

This map unit is in capability subclass VIIe.

13—Akina-Atate silty clays, 0 to 7 percent slopes. This map unit is on volcanic uplands. Slopes are short and plane. The vegetation is mainly forest. Some areas are in grasses and forbs. Elevation is 100 to 250 meters.

This unit is 50 percent Akina silty clay and 40 percent Atate silty clay. The components of this unit are so intricately intermingled that it was not practical to map them separately.

The Akina soil is very deep and well drained. It formed in residuum derived dominantly from tuff and tuff breccia. Typically, the surface layer is dark reddish brown silty clay about 10 centimeters thick. The subsoil is dark red clay about 51 centimeters thick. Mixed dark red and white silty clay saprolite is at a depth of 61 centimeters. Depth to saprolite ranges from 51 to 102 centimeters. The soil is very strongly acid to strongly acid throughout.

Permeability of this Akina soil is moderately slow. Available water capacity is moderate. Effective rooting depth is 150 centimeters or more. Runoff is medium, and the hazard of water erosion is slight.

The Atate soil is very deep and is well drained. It formed in residuum derived dominantly from tuff and tuff breccia. Typically, the surface layer is dark reddish brown silty clay about 13 centimeters thick. The subsurface layer is dark reddish brown clay about 17 centimeters thick. The subsoil is yellowish red and dark red clay about 135 centimeters thick. The soil is strongly acid to medium acid.

Permeability of this Atate soil is moderate. Available water capacity is moderate. Effective rooting depth is 150 centimeters or more. Runoff is medium, and the hazard of water erosion is slight.

Included in this unit are small areas of Togcha soils. Also included are small areas of soils that have an eroded surface layer, Badland consisting of areas that have been severely gullied to expose the substratum, and soils that are sloping. Included areas make up about 10 percent of the total hectarage.

This unit is used as wildlife habitat and watershed. It can be used for grazing, subsistence and commercial farming, and homesite and recreational development.

The use of this unit as wildlife habitat and watershed can be enhanced by protecting the unit from wildfires and by planting adapted trees. Establishing firebreaks and restricting public access can help to prevent wildfires. Prescribed burning of adjacent cropland should be closely supervised. Forest cover improves the watershed by reducing surface runoff and erosion. It also provides valuable cover for wildlife.

This unit is well suited to grazing in areas not heavily forested. The quality of tropical forage is extremely low if it is allowed to mature. Livestock rotation improves the quality of forage and helps to prevent erosion caused by overstocking and trailing. The quality of forage can be improved by introducing adapted grasses and legumes. Yield can be increased by fertilizing and liming. Practices such as salting, constructing livestock watering facilities, fencing, mowing or dragging, and protecting the unit from fire can be used to enhance the carrying capacity of the soil and to prevent erosion.

This unit is moderately suited to subsistence farming. Crushed coral limestone can be mixed into the soil to provide calcium and to reduce soil acidity. Compost can be applied to improve soil fertility.

This unit is moderately suited to commercial farming. Crops that can be grown are those adapted to acidic soils, including watermelon, head and Chinese cabbages, and fruit trees. It is limited mainly by the hazard of erosion, low soil fertility, soil acidity, and lack of water during the dry season. All tillage should be across the slope. Erosion can be reduced by avoiding

clean cultivation, by installing diversions, terraces, or grassed waterways, and by planting cover crops. Crops respond to fertilizer and lime. The organic matter content can be maintained by rotating crops and by plowing under cover crops and all crop residue. During the dry season, irrigation is required for maximum production of row crops. Drip irrigation is suited to this unit. Windbreaks are needed for the production of crops.

This unit is moderately suited to homesite development. If the unit is used for roads, the main limitation is low soil strength. The load bearing capacity of the soil can be improved by spreading gravel fill before constructing buildings and roads. Preserving the existing plant cover during construction helps to control erosion. Topsoil can be stockpiled and used to reclaim areas disturbed during construction. Revegetating disturbed areas around construction sites as soon as possible helps to control soil erosion.

If this unit is used for septic tank absorption fields, the limitation of moderately slow permeability in the Akina soil can be overcome by increasing the size of the absorption field. If the density of housing is moderate to high, community sewage systems are needed to prevent contamination of local streams as a result of seepage from onsite sewage disposal systems.

The main limitation of this unit for recreational development is the low soil strength. The load bearing capacity of the soil can be improved by spreading gravel fill before constructing roads, buildings, and trails. Plant cover can be maintained by limiting traffic.

This map unit is in capability subclass IIe.

14—Akina-Atate silty clays, 7 to 15 percent slopes. This map unit is on volcanic uplands. Slopes are long and plane. The vegetation is mainly forest. Some areas are in grasses and forbs. Elevation is 100 to 250 meters.

This unit is 50 percent Akina silty clay and 40 percent Atate silty clay. The components of this unit are so intricately intermingled that it was not practical to map them separately.

The Akina soil is very deep and well drained. It formed in residuum derived dominantly from tuff and tuff breccia. Typically, the surface layer is dark reddish brown silty clay about 10 centimeters thick. The subsoil is dark red clay about 51 centimeters thick. Mixed dark red and white silty clay saprolite is at a depth of 61 centimeters. Depth to saprolite ranges from 51 to 102 centimeters. The soil is very strongly acid to strongly acid in the subsoil and underlying saprolite.

Permeability of this Akina soil is moderately slow. Available water capacity is moderate. Effective rooting depth is 150 centimeters or more. Runoff is medium, and the hazard of water erosion is moderate.

The Atate soil is very deep and well drained. It formed in residuum derived dominantly from tuff and tuff breccia. Typically, the surface layer is dark reddish brown silty clay about 13 centimeters thick. The subsurface layer is dark reddish brown clay about 17 centimeters thick. The subsoil is yellowish red and dark red clay about 135 centimeters thick. The soil is medium acid to strongly acid.

Permeability of this Atate soil is moderate. Available water capacity is moderate. Effective rooting depth is 150 centimeters or more. Runoff is medium, and the hazard of water erosion is moderate.

Included in this unit are small areas of Togcha soils on lower slopes. Also included are small areas of soils that have an eroded surface layer, Badland consisting of areas that have been severely gullied to expose the substratum, soils that are nearly level and are on ridgelines and toe slopes, and soils that have short, moderately steep slopes. Included areas make up about 10 percent of the total hectarage.

This unit is used as wildlife habitat and watershed. It can be used for grazing, subsistence and commercial farming, and homesite and recreational development.

The use of this unit as wildlife habitat and watershed can be enhanced by protecting the unit from wildfires and by planting adapted trees in areas of savannah vegetation. Establishing firebreaks and restricting public access can help to prevent wildfires. Prescribed burning of adjacent cropland should be closely supervised. Forest cover improves the watershed by reducing surface runoff and erosion. It also provides valuable cover for wildlife.

This unit is well suited to grazing. The quality of tropical forage is extremely low if it is allowed to mature. Livestock rotation improves the quality of forage and helps to prevent erosion caused by overstocking and trailing. The quality of forage can be improved by introducing adapted grasses and legumes. Yield can be increased by fertilizing and liming. Practices such as salting, constructing livestock watering facilities, fencing, mowing or dragging, and protecting the unit from fire can be used to enhance the carrying capacity of the soil and to prevent erosion.

This unit is moderately suited to subsistence farming. The main limitations are low soil fertility, soil acidity, the hazard of erosion, and the lack of water during the dry season. Compost can be applied to improve soil fertility. Crushed coral limestone can be mixed into the soil to provide calcium and to reduce soil acidity. Clean cultivation should be avoided. Weeds can be controlled by mulching and mowing. During the dry season, irrigation is needed for shallow-rooted vegetables. Growth and production of banana, papaya, and other fruit trees can be increased by irrigating during the dry season.

This unit is moderately suited to commercial farming. Crops that can be grown include watermelons, head and Chinese cabbages, and fruit trees that are adapted to clayey, acidic soils. The main limitations are the hazard of erosion, low soil fertility, soil acidity, and lack of water during the dry season. All tillage should be across the

slope. Erosion can be reduced by avoiding clean cultivation, by installing diversions, terraces, or grassed waterways, and by planting cover crops. Crops respond to fertilizer and lime. The organic matter content can be maintained by rotating crops and by plowing under cover crops and all crop residue. During the dry season, irrigation is required for maximum production of crops. Drip irrigation is suited to this unit. Windbreaks are needed for the production of crops.

This unit is moderately suited to homesite development. The main limitation is slope. Preserving the existing plant cover during construction helps to control erosion. Topsoil can be stockpiled and used to reclaim areas disturbed during construction. Revegetating disturbed areas around construction sites as soon as possible helps to control soil erosion. If the unit is used for roads, the main limitation is low soil strength. The load bearing capacity of the soil can be improved by spreading gravel fill before constructing buildings and roads.

If this unit is used for septic tank absorption fields, the limitation of moderately slow permeability in the Akina soil can be overcome by increasing the size of the absorption field. Slope is a concern in installing septic tank absorption fields. Absorption lines should be installed on the contour. If the density of housing is moderate to high, community sewage systems are needed to prevent contamination of local streams as a result of seepage from onsite sewage disposal systems.

The main limitations of this unit for recreational development are the hazard of erosion and slope. Plant cover can be maintained by limiting traffic. Playgrounds, ball fields, and other recreation areas that require level sites are difficult to establish on this unit.

This map unit is in capability subclass IIIe.

15—Akina-Atate silty clays, 15 to 30 percent slopes. This map unit is on volcanic uplands. Slopes are long and plane. The vegetation is mainly forest. Some areas are in grasses and forbs. Elevation is 100 to 250 meters.

This unit is 50 percent Akina silty clay and 40 percent Atate silty clay. The components of this unit are so intricately intermingled that it was not practical to map them separately.

The Akina soil is very deep and well drained. It formed in residuum derived dominantly from tuff and tuff breccia. Typically, the surface layer is dark reddish brown silty clay about 10 centimeters thick. The subsoil is dark red clay about 51 centimeters thick. Mixed dark red and white silty clay saprolite is at a depth of 61 centimeters. Depth to saprolite ranges from 51 to 102 centimeters. The soil is very strongly acid to strongly acid.

Permeability of this Akina soil is moderately slow. Available water capacity is moderate. Effective rooting depth is 150 centimeters or more. Runoff is rapid, and the hazard of water erosion is severe.

The Atate soil is very deep and well drained. It formed in residuum derived dominantly from tuff and tuff breccia. Typically, the surface layer is dark reddish brown silty clay about 13 centimeters thick. The subsurface layer is dark reddish brown clay about 17 centimeters thick. The subsoil is yellowish red and dark red clay about 135 centimeters thick. The soil is strongly acid to medium acid.

Permeability of this Atate soil is moderate. Available water capacity is moderate. Effective rooting depth is 150 centimeters or more. Runoff is rapid, and the hazard of water erosion is severe.

Included in this unit are small areas of Togcha soils on lower slopes. Also included are small areas of soils that have an eroded surface layer, Badland consisting of areas that have been severely gullied to expose the substratum, soils that are gently sloping and are on ridgelines and benches, and soils that have short, steep slopes. Included areas make up about 10 percent of the total hectarage.

This unit is used as wildlife habitat and watershed. It can be used for grazing, subsistence farming, homesite development, and recreation. The unit is not suited to commercial farming.

The use of this unit as wildlife habitat and watershed can be enhanced by protecting the unit from wildfires and by planting adapted trees in areas of savannah vegetation. Establishing firebreaks and restricting public access can help to prevent wildfires. Prescribed burning of adjacent cropland should be closely supervised. Forest cover improves the watershed by reducing surface runoff and erosion. It also provides valuable cover for wildlife.

This unit is moderately suited to grazing in areas not heavily forested. The main limitation is the hazard of gully erosion caused by continuous grazing. The quality of tropical forage is extremely low if it is allowed to mature. Livestock rotation improves the quality of forage and helps to prevent erosion caused by overstocking and trailing. The quality of forage can be improved by introducing adapted grasses and legumes. Yield can be increased by fertilizing and liming. Practices such as salting, constructing livestock watering facilities, fencing, mowing or dragging, and protecting the unit from fire can be used to enhance the carrying capacity of the soil and to prevent erosion.

This unit is poorly suited to subsistence farming. The main limitations are the hazard of erosion, low soil fertility, soil acidity, and the lack of water during the dry season. Clean cultivation should be avoided. Weeds can be controlled by mulching and mowing. Compost can be applied to improve soil fertility. Crushed coral limestone can be mixed into the soil to provide calcium and to reduce soil acidity. During the dry season, irrigation is needed for shallow-rooted vegetables. Growth and production of banana, papaya, and other fruit trees can be increased by irrigating during the dry season.

This unit is poorly suited to homesite development. The main limitation is slope. Slopes are too steep for conventional construction techniques. Only isolated ridgelines and hilltops can be used as construction sites. Preserving the existing plant cover during construction helps to control erosion. Topsoil can be stockpiled and used to reclaim areas disturbed during construction. Revegetating disturbed areas around construction sites as soon as possible helps to control soil erosion. If the unit is used for roads, the main limitations are low soil strength and slope. The load bearing capacity of the soil can be improved by spreading gravel fill before constructing buildings and roads.

If this unit is used for septic tank absorption fields, the limitation of moderately slow permeability in the Akina soil can be overcome by increasing the size of the absorption field. Slope is a concern in installing septic tank absorption fields. Absorption lines should be installed on the contour. Specialized designs are needed to overcome the limitation of slope.

Because of the clayey soil texture, slope, and the hazard of erosion, the recreational use of this unit is limited mainly to a few paths and trails, which should extend across the slope. Erosion and sedimentation can be controlled and the beauty of the area enhanced by maintaining adequate plant cover. Plant cover can be maintained by limiting traffic.

This map unit is in capability subclass VIe.

16—Akina-Atate silty clays, 30 to 60 percent slopes. This map unit is on volcanic uplands. Slopes are long and plane. The vegetation is mainly forest. Some areas are in grasses and forbs. Elevation is 100 to 250 meters.

This unit is 50 percent Akina silty clay and 40 percent Atate silty clay. The components of this unit are so intricately intermingled that it was not practical to map them separately.

The Akina soil is very deep and well drained. It formed in residuum derived dominantly from tuff and tuff breccia. Typically, the surface layer is dark reddish brown silty clay about 10 centimeters thick. The subsoil is dark red clay about 51 centimeters thick. Mixed dark red and white silty clay saprolite is at a depth of 61 centimeters. Depth to saprolite ranges from 51 to 102 centimeters. The soil is very strongly acid to strongly acid throughout.

Permeability of this Akina soil is moderately slow. Available water capacity is moderate. Effective rooting depth is 150 centimeters or more. Runoff is rapid, and the hazard of water erosion is severe.

The Atate soil is very deep and well drained. It formed in residuum derived dominantly from tuff and tuff breccia. Typically, the surface layer is dark reddish brown silty clay about 13 centimeters thick. The subsurface layer is dark reddish brown clay about 17 centimeters thick. The subsoil is yellowish red and dark red clay about 135 centimeters thick. The soil is strongly acid to medium acid.

Permeability of this Atate soil is moderate. Available water capacity is moderate. Effective rooting depth is 150 centimeters or more. Runoff is rapid, and the hazard of water erosion is severe.

Included in this unit are small areas of soils that have a gravelly and cobbly surface layer and Agfayan soils. Also included are small areas of soils that have an eroded surface layer, Badland consisting of areas that have been severely gullied to expose the substratum, and soils that are moderately steep and are on ridgelines and benches. Included areas make up about 10 percent of the total hectarage.

This unit is used as wildlife habitat and watershed. It can be used for recreation. The unit is not suited to grazing, subsistence or commercial farming, and homesite development.

The use of this unit as wildlife habitat and watershed can be enhanced by protecting the unit from wildfires and by planting adapted trees in areas of savannah vegetation. Establishing firebreaks and restricting public access can help to prevent wildfires. Prescribed burning of adjacent cropland should be closely supervised. Forest cover improves the watershed by reducing surface runoff and erosion. It also provides valuable cover for wildlife.

Because of the clayey soil texture and slope, the recreational use of this unit is limited mainly to a few paths and trails, which should extend across the slope and along ridgelines.

This map unit is in capability subclass VIIe.

17—Akina-Atate association, steep. This map unit is on mountainous volcanic uplands in the interior, high elevation areas of southern Guam. Slope is 20 to 60 percent. Slopes are long and plane and are dissected in the steeper areas. The vegetation is mainly forest. Elevation is 30 to 300 meters.

This unit is 55 percent Akina silty clay and 35 percent Atate silty clay. The components are not in a predictable pattern.

The Akina soil is very deep and well drained. It formed in residuum derived dominantly from tuff and tuff breccia. Typically, the surface layer is dark reddish brown silty clay about 10 centimeters thick. The subsoil is dark red clay about 51 centimeters thick. Mixed red and white silty clay saprolite is at a depth of 61 centimeters. Depth to saprolite ranges from 51 to 102 centimeters. The subsoil and underlying saprolite are very strongly acid to strongly acid.

Permeability of this Akina soil is moderately slow. Available water capacity is moderate. Effective rooting depth is 150 centimeters or more. Runoff is rapid, and the hazard of water erosion is severe.

The Atate soil is very deep and well drained. It formed in residuum derived dominantly from tuff and tuff breccia.

Typically, the surface layer is dark reddish brown silty clay about 13 centimeters thick. The subsurface layer is dark reddish brown clay about 17 centimeters thick. The subsoil is yellowish red and dark red clay about 135 centimeters thick. The soil is medium acid throughout.

Permeability of this Atate soil is moderate. Available water capacity is moderate. Effective rooting depth is 150 centimeters or more. Runoff is rapid, and the hazard of water erosion is severe.

Included in this unit are small areas of Togcha soils on lower slopes and benches, Ylig soils on drainage bottoms and in depressional areas, and soils that are underlain by soft bedrock and have steep and very steep slopes. Also included are small areas of soils on gently sloping ridgelines, benches, and valley bottoms, Badland, Agfayan soils, and soils that have short, extremely steep slopes. Included areas make up about 10 percent of the total hectarage.

This unit is used as watershed and wildlife habitat. It is not suited to grazing, subsistence or commercial farming, or homesite development. The main limitations are steepness of slope and the hazard of erosion.

The use of this unit as wildlife habitat and watershed can be enhanced by maintaining the forest cover and protecting the unit from wildfires.

Slope limits the recreational use of this unit mainly to a few paths and trails, which should extend across the slope and along ridgelines. Plant cover can be maintained by limiting traffic.

This map unit is in capability subclass VIIe.

18—Akina-Badland complex, 7 to 15 percent slopes. This map unit is on volcanic uplands. Slopes generally are long and plane, but short, steep dropoffs and ravines are present in the areas of Badland. The vegetation on the Akina soil is mainly grasses and forbs. The areas of Badland support little if any vegetation. Elevation is 50 to 320 meters.

This unit is 65 percent Akina silty clay and 30 percent Badland. The components of this unit are so intricately intermingled that it was not practical to map them separately.

The Akina soil is very deep and well drained. It formed in residuum derived dominantly from tuff and tuff breccia. Typically, the surface layer is dark reddish brown silty clay about 10 centimeters thick. The subsoil is dark red clay about 51 centimeters thick. Mixed dark red and white silty clay saprolite is at a depth of 61 centimeters. Depth to saprolite ranges from 51 to 102 centimeters. The soil is very strongly acid to strongly acid throughout.

Permeability of this Akina soil is moderately slow. Available water capacity is moderate. Effective rooting depth is 150 centimeters or more. Runoff is medium, and the hazard of water erosion is moderate.

Badland is actively eroding areas of very deep, well drained saprolite derived from tuff and tuff breccia (fig. 6). It supports little if any vegetation. Slopes are short and irregular, and they range from moderately sloping to vertical. Gullies and ravines are common. The saprolite is variegated dark red and white, and it crushes easily to silty clay or clay.

Permeability of the Badland is moderately slow. Runoff is rapid, and the hazard of water erosion is severe.

Included in this unit are small areas of Atate soils and Togcha soils on lower slopes. Also included are small areas of Akina soils that have an eroded surface layer, Agfayan soils, soils that are nearly level, and soils that have short, moderately steep slopes. Included areas make up about 5 percent of the total hectarage.

This unit is used mainly as watershed and wildlife habitat.

The use of this unit as wildlife habitat and watershed can be enhanced by protecting the unit from wildfires and by planting adapted trees. Establishing firebreaks and restricting public access can help to prevent wildfires. Prescribed burning of adjacent cropland should be closely supervised. Forest cover improves the watershed by reducing surface runoff and erosion. It also provides valuable cover for wildlife.

This unit is not suited to commercial farming. The areas of Badland restrict the use of tractor-mounted tillage equipment.

The main limitation of this unit for recreational development is the hazard of erosion. Plant cover can be maintained by limiting traffic. Playgrounds, ball fields, and other recreation areas that require level sites are difficult to establish on this unit.

The Akina soil is in capability subclass IIIe, and the Badland is in capability subclass VIIIe.

19—Akina-Badland complex, 15 to 30 percent slopes. This map unit is on volcanic uplands. Slopes generally are long and plane, but short, steep dropoffs and ravines are present in the areas of Badland. The vegetation on the Akina soil is mainly grasses and forbs. The areas of Badland support little if any vegetation. Elevation is 50 to 320 meters.

This unit is 65 percent Akina silty clay and 30 percent Badland. The components of this unit are so intricately intermingled that it was not practical to map them separately.

The Akina soil is very deep and well drained. It formed in residuum derived dominantly from tuff and tuff breccia. Typically, the surface layer is dark reddish brown silty clay about 10 centimeters thick. The subsoil is dark red clay about 51 centimeters thick. Mixed dark red and white silty clay saprolite is at a depth of 61 centimeters. Depth to saprolite ranges from 51 to 102 centimeters. The soil is very strongly acid to strongly acid throughout.

Permeability of this Akina soil is moderately slow. Available water capacity is moderate. Effective rooting depth is 150 centimeters or more. Runoff is rapid, and the hazard of water erosion is severe.

Figure 6.—Badland in an area of Akina-Badland complex, 7 to 15 percent slopes. Akina silty clay is under grasses directly above the Badland scar.

Badland is actively eroding areas of very deep, well drained saprolite derived from tuff and tuff breccia. It supports little if any vegetation. Slopes are short and irregular, and they range from moderately sloping to vertical. Gullies and ravines are common. The saprolite is variegated dark red and white, and it crushes easily to silty clay or clay.

Permeability of the Badland is moderately slow. Runoff is rapid, and the hazard of water erosion is severe.

Included in this unit are small areas of Atate soils and Togcha soils on lower slopes. Also included are small areas of Akina soils that have an eroded surface layer, Agfayan soils, and soils that are gently sloping and are on ridgelines and benches. Included areas make up about 5 percent of the total hectarage.

This unit is used mainly as watershed and wildlife habitat.

The use of this unit as wildlife habitat and watershed can be enhanced by protecting the unit from wildfires and by planting adapted trees. Establishing firebreaks and restricting public access can help to prevent wildfires. Prescribed burning of adjacent cropland should be closely supervised. Forest cover improves the

watershed by reducing surface runoff and erosion. It also provides valuable cover for wildlife.

Slope limits the recreational use of this unit mainly to a few paths and trails, which should extend across the slope. Erosion and sedimentation can be controlled and the beauty of the area enhanced by maintaining adequate plant cover. Plant cover can be maintained by limiting traffic.

The Akina soil is in capability subclass VIe, and the Badland is in capability subclass VIIIe.

20—Akina-Badland complex, 30 to 60 percent slopes. This map unit is on volcanic uplands. Slopes generally are long and plane, but short, extremely steep dropoffs and ravines are present in the areas of Badland. The vegetation on the Akina soil is mainly grasses and forbs. The areas of Badland support little if any vegetation. Elevation is 50 to 320 meters.

This unit is 65 percent Akina silty clay and 30 percent Badland. The components of this unit are so intricately intermingled that it was not practical to map them separately.

The Akina soil is very deep and well drained. It formed in residuum derived dominantly from tuff and tuff breccia. Typically, the surface layer is dark reddish brown silty clay about 10 centimeters thick. The subsoil is dark red clay about 51 centimeters thick. Mixed dark red and white silty clay saprolite is at a depth of 61 centimeters. Depth to saprolite ranges from 51 to 102 centimeters. The soil is very strongly acid to strongly acid throughout.

Permeability of this Akina soil is moderately slow. Available water capacity is moderate. Effective rooting depth is 150 centimeters or more. Runoff is rapid, and the hazard of water erosion is severe.

Badland is actively eroding areas of very deep, well drained saprolite derived from tuff and tuff breccia. It supports little if any vegetation. Slopes are short and irregular, and they range from moderately sloping to vertical. Gullies and ravines are common. The saprolite is variegated dark red and white, and it crushes easily to silty clay or clay.

Permeability of the Badland is moderately slow. Runoff is rapid, and the hazard of water erosion is severe.

Included in this unit are small areas of Agfayan soils. Also included are small areas of Akina soils that have an eroded surface layer and soils that are gently sloping to moderately sloping and are on ridgelines and benches. Included areas make up about 5 percent of the total hectarage.

This unit is used as watershed and wildlife habitat. It can be used for recreation.

The use of this unit as wildlife habitat and watershed can be enhanced by protecting the unit from wildfires and by planting adapted trees. Establishing firebreaks and restricting public access can help to prevent wildfires. Prescribed burning of adjacent cropland should be closely supervised. Forest cover improves the watershed by reducing surface runoff and erosion. It also provides valuable cover for wildlife.

Slope limits the recreational use of this unit mainly to a few paths and trails, which should extend across the slope and along ridgelines.

The Akina soil is in capability subclass VIIe, and the Badland is in capability subclass VIIIe.

21—Akina-Badland association, steep. This map unit is on mountainous, volcanic uplands in the interior, high elevation areas of southern Guam. Slope is 20 to 60 percent. Slopes are long and rolling and are dissected by steep-sided ravines. The vegetation is mainly grasses with some forest on ravine bottoms. The areas of Badland are barren. Elevation is 50 to 330 meters.

This unit is 60 percent Akina silty clay on upper slopes and ridgelines and 25 percent Badland on summits and shoulder slopes. The components of this unit are so intricately intermingled that it was not practical to map them separately.

The Akina soil is very deep and well drained. It formed in residuum derived dominantly from tuff and tuff breccia. Typically, the surface layer is dark reddish brown silty clay about 10 centimeters thick. The subsoil is dark red clay about 51 centimeters thick. Mixed red and white silty clay saprolite is at a depth of 61 centimeters. Depth to saprolite ranges from 51 to 102 centimeters. In some areas the upper part of the soil formed in alluvium. The soil is very strongly acid to strongly acid throughout.

Permeability of this Akina soil is moderately slow. Available water capacity is moderate. Effective rooting depth is 150 centimeters or more. Runoff is rapid, and the hazard of water erosion is severe.

Badland is actively eroding areas of very deep, well drained saprolite derived from tuff and tuff breccia. It supports little if any vegetation. Slopes are short and irregular, and they range from moderately sloping to vertical. Gullies and ravines are common. The saprolite is variegated dark red and white, and it crushes easily to silty clay or clay.

Permeability of the Badland is moderately slow. Runoff is rapid, and the hazard of water erosion is severe.

Included in this unit is about 10 percent Togcha soils on broad, gently sloping lower benches. Also included is about 5 percent Atate soils, Agfayan soils in steeper areas and on knobs, soils that are nearly level to gently sloping and are on ridgelines and benches, Ylig soils in drainageways, and soils in stream channels that have been incised to bedrock.

This unit is used as watershed and wildlife habitat. It is also used for off-road vehicle recreation.

The use of this unit as wildlife habitat and watershed can be enhanced by protecting the unit from wildfires and by planting adapted trees. Establishing firebreaks and restricting public access can help to prevent wildfires. Prescribed burning of adjacent cropland should

be closely supervised. Forest cover improves the watershed by reducing surface runoff and erosion. It also provides valuable cover for wildlife.

Slope limits the recreational use of this unit mainly to a few paths and trails, which should extend across the slope and along ridgelines. Plant cover can be maintained by limiting traffic.

The Akina soil is in capability subclass VIIe. The Badland is in capability subclass VIIIe.

22—Akina-Urban land complex, 0 to 7 percent slopes. This unit is on volcanic uplands. Most areas have been disturbed by land shaping for urban development. Many areas are covered by roads, buildings, and parking lots. Elevation is sea level to 320 meters.

This unit is about 60 percent Akina silty clay and 30 percent Urban land. The components of this unit are so intricately intermingled that it was not practical to map them separately.

The Akina soil is very deep and well drained. It formed in residuum derived from tuff and tuff breccia. Typically, the surface layer and the upper part of the subsoil have been removed or mixed with the underlying material during construction. The subsoil is dark red clay about 51 centimeters thick. Below this to a depth of 150 centimeters or more is mixed dark red and white silty clay saprolite. Depth to saprolite commonly is 51 to 102 centimeters, but it varies considerably because of cutting, filling, and leveling. The soil is very strongly acid to strongly acid except where coral gravel has been mixed into the surface layer.

Permeability of this Akina soil is moderately slow. Available water capacity is moderate. Effective rooting depth is 150 centimeters or more. Runoff is medium, and the hazard of water erosion is slight.

Urban land consists of areas covered with roads, buildings, and parking lots. Coral gravel is used as base material for these structures.

Included in this unit are Agfayan soils and areas where saprolite is exposed as a result of construction activities. Included areas make up about 10 percent of the total hectarage.

This unit is used as homesites, as commercial and industrial sites, and for other urban uses.

This unit is moderately suited to homesite development. If it is used for roads, the main limitation is low soil strength. The load bearing capacity can be improved by spreading gravel fill before constructing buildings and roads. Topsoil can be stockpiled and used to reclaim areas disturbed by cutting and filling. Revegetating disturbed areas around construction sites as soon as possible helps to control soil erosion. Fertilizing, liming, and irrigating are necessary for the establishment of lawns and landscaping plants.

The Akina soil is in capability subclass IIe.

23—Chacha clay, 0 to 5 percent slopes. This very deep, somewhat poorly drained soil is in broad depressional areas on plateaus. It formed in sediment derived dominantly from argillaceous limestone and volcanic saprolite. Slopes are long and concave. The vegetation in areas not cultivated is mainly grasses and tangantangan. Elevation is 40 to 100 meters.

Typically, the surface layer is dark brown clay about 20 centimeters thick. The subsoil to a depth of about 109 centimeters is dominantly strong brown clay. The surface layer and subsoil have many black manganese concretions. The substratum to a depth of more than 150 centimeters is mixed strong brown, red, and white, highly weathered saprolite. Depth to saprolite ranges from 102 to 150 centimeters or more. The surface layer is medium acid, and the subsoil is neutral to mildly alkaline.

Included in this unit are small areas of poorly drained Chacha Variant soils. Also included are small areas of Pulantat soils on upper slopes and in convex areas, Kagman soils, Saipan soils, and sloping Chacha soils. Included areas make up about 10 percent of the total hectarage.

Permeability of this Chacha soil is slow. Available water capacity is moderate. Effective rooting depth is 150 centimeters or more. Runoff is ponded or very slow, and the hazard of water erosion is slight. These soils are saturated between depths of 51 and 91 centimeters for significant periods during the rainy season as a result of an intermittent perched water table. Ponding can occur in level areas following periods of high rainfall.

Most areas of this unit are used for commercial and subsistence farming. A few areas are used for grazing, homesites, watershed, and wildlife habitat. The unit can be used for recreational development.

This unit is moderately suited to subsistence farming. The main limitations are wetness during the rainy season, the hazard of soil compaction when the soil is wet, and the lack of water late in the dry season. Wetness can be reduced by using raised beds for crop production. Ditches can be used to remove excess water if a suitable outlet is available. Farming in the lower lying areas may not be feasible during the rainy season. Banana, papaya, and other fruit trees should be planted on the upper slopes. Mechanical tillage and vehicle traffic should be avoided when the soil is wet. Weeds can be controlled by mulching or mowing. During the dry season, irrigation is needed for shallow-rooted vegetables. Growth and production of banana, papaya, and other fruit trees can be increased by irrigating during the dry season.

This unit is moderately suited to commercial farming. Vegetable crops grown during the dry season include beans, watermelons, Chinese and head cabbages, cantaloupes, and cucumbers. The unit is moderately suited to banana, tangerine, and other fruit trees that are planted on the upper slopes. The main limitations are

wetness during the rainy season, the hazard of compaction when the soil is wet, and the lack of water late in the dry season. Farming of this unit is not feasible during the rainy season. Field operations should be avoided after heavy rains. Using raised beds for crops helps to overcome the problem of wetness. Ditches or a subsurface drainage system can be used to remove excess water if a suitable outlet is available. All tillage should be across the slope. Erosion can be reduced by avoiding clean cultivation, by installing diversions, terraces, or grassed waterways, and by planting cover crops. During the dry season, irrigation is required for maximum production of row crops. Drip irrigation is suited to this unit. Windbreaks are needed for the production of crops. The organic matter content can be maintained by rotating crops and by plowing under cover crops and all crop residue. Crops respond to fertilizer.

This unit is well suited to grazing. Livestock should be removed when the soil is ponded. Livestock rotation provides needed rest from grazing and improves the quality of forage. The quality of forage can also be improved by introducing adapted grasses and legumes. Yield can be increased by fertilizing. Production of tangantangan trees can be improved by cutting them at a suitable height for grazing. Practices such as salting, constructing livestock watering facilities, fencing, mowing or dragging, and protecting the unit from fire can be used to enhance the carrying capacity of the soil.

This unit is poorly suited to homesite development. The main limitations are a high shrink-swell potential, low soil strength, and wetness during the rainy season. The main limitations for roads are a high shrink-swell potential and low soil strength. The effects of shrinking and swelling can be minimized by using proper engineering designs and by removing the soil and backfilling with suitable material. The load bearing capacity of the soil can be improved by spreading gravel fill before constructing buildings and roads. Excess water can be removed by using drainage ditches, foundation drains, and proper grading. Cutbanks are not stable and are subject to slumping. Revegetating disturbed areas around construction sites as soon as possible helps to control soil erosion.

Septic tank absorption fields do not function properly because of the seasonal perched water table and slow permeability.

The use of this unit as wildlife habitat and watershed can be enhanced by maintaining the forest cover. Low-lying areas, which are ponded during the rainy season, provide habitat for Mariana gallinule and other wildlife species.

The main limitations of this unit for recreational development are the clayey soil texture and wetness during the rainy season. Drainage should be provided for paths and trails. Plant cover can be maintained by limiting traffic.

This map unit is in capability subclass IIIw.

24—Chacha Variant clay, 0 to 3 percent slopes. This very deep, poorly drained soil is in depressional areas on limestone plateaus. The surface is hummocky in many areas. The soil formed in sediment derived dominantly from argillaceous limestone. Areas are round or elongated in shape and are 4 to 10 hectares in size. The vegetation is mainly water tolerant grasses. Elevation is 60 to 150 meters.

Typically, the surface layer is very dark grayish brown and grayish brown clay 28 centimeters thick. The upper part of the subsoil is dark brown to dark yellowish brown clay about 42 centimeters thick, and the lower part to a depth of 150 centimeters or more is strong brown clay with some light gray mottles. Manganese concretions are common in the profile. The soil is neutral to mildly alkaline.

Included in this unit are small areas of Chacha and Pulantat soils in slightly higher lying areas. Also included are small areas of Ylig soils along drainageways. Included areas make up about 10 percent of the total hectarage.

Permeability of this Chacha Variant soil is slow. Available water capacity is moderate. Effective rooting depth is 150 centimeters or more. Runoff is ponded, and the hazard of water erosion is slight. This soil is ponded for significant periods during the rainy season. Surface cracks may occur during the dry season.

This unit is used for commercial and subsistence farming, grazing, watershed, and wildlife habitat. It is not suited to homesite or recreational development.

This unit is poorly suited to subsistence farming. The main limitations are wetness during the rainy season and the lack of water late in the dry season. The unit is well suited to taro and other crops that tolerate seasonal wetness. Most vegetables cannot be grown during the rainy season. This unit is not suited to bananas, tangerines, and other fruit crops. During the dry season, irrigation is needed for shallow-rooted vegetables.

This unit is poorly suited to commercial farming. The main limitations are wetness during the rainy season, the susceptibility of the soil to compaction when it is moist, and the lack of water during the dry season. Vegetables that can be grown late in the dry season include watermelons, Chinese and head cabbages, cantaloupes, and cucumbers. The unit is not suited to bananas, tangerines, and other fruit crops that are sensitive to soil wetness. Farming this soil is not feasible during the rainy season. Irrigation is needed for maximum production of row crops. Drip irrigation is suited to this unit. The organic matter content can be maintained by rotating crops and by plowing under cover crops and all crop residue. Crops respond to fertilizer.

The use of this unit as wildlife habitat and watershed can be enhanced by preserving the plant cover and protecting the seasonal ponds from pollutants. Pond development and other practices that increase the

duration of ponds while preserving the surrounding vegetation enhance the habitat.

This unit is poorly suited to grazing. The main limitations are ponding during the rainy season and the susceptibility of the soil to compaction when it is moist. Livestock should be removed when the unit is ponded. Practices such as salting, constructing livestock watering facilities, fencing, mowing or dragging, and protecting the unit from fire can be used to enhance the carrying capacity of the soil.

This map unit is in capability subclass IVw.

25—Guam cobbly clay loam, 3 to 7 percent slopes. This very shallow, well drained soil is on limestone plateaus. It formed in sediment overlying porous coralline limestone. Slopes are undulating. The vegetation in areas not cultivated is mainly forest. Elevation is 30 to 200 meters.

Typically, 5 to 10 percent of the surface is covered with gravel and cobbles. The surface layer is dark reddish brown cobbly clay loam about 5 centimeters thick. The subsoil is dusky red gravelly clay loam about 15 centimeters thick. Limestone is at a depth of 20 centimeters. Depth to limestone ranges from 5 to 41 centimeters. In some places, a thin layer of soft, fractured limestone is below the subsoil. The deeper areas commonly are nongravelly, and the shallower areas commonly are very gravelly. The soil is neutral to mildly alkaline.

Included in this unit are small areas of Yigo soils in depressional areas. Also included are small areas of coral Rock outcrop and Ritidian soils that commonly are on shoulder slopes and in sloping areas and Guam soils in nearly level to moderately sloping areas. Limestone quarries are in some areas. Included areas make up about 10 percent of the total hectarage.

Permeability of this Guam soil is moderately rapid. Available water capacity is very low. Effective rooting depth is 5 to 41 centimeters. Roots enter the limestone along cracks and pores. Runoff is slow, and the hazard of water erosion is slight.

This unit is used for commercial and subsistence farming, homesite and recreational development, watershed, and wildlife habitat. It can be used for grazing.

This unit is poorly suited to subsistence farming. The main limitations are the very shallow soil depth and droughtiness. Banana, tangerine, and other fruit trees should be planted only in the deeper areas. In most areas the bedrock should be excavated to a depth of at least 50 centimeters and the area backfilled with soil before planting trees. Irrigation is needed for vegetables. Growth and production of banana, papaya, and other fruit trees can be increased by irrigating during the dry season. Compost can be applied to improve soil fertility.

This unit is poorly suited to commercial production of vegetables, and it is not suited to commercial production of fruit. The main limitations are the very shallow soil depth, droughtiness, and cobbles. With proper management, most vegetables can be grown throughout the year. Drip irrigation is suited to this unit. Light, frequent applications of irrigation water are needed. Windbreaks are needed for the production of crops. In some areas excessive gravel and cobbles must be removed. Crops respond to fertilizer. Foliar applications of micronutrients improve yields of many crops. The organic matter content can be maintained by rotating crops and by plowing under cover crops and all crop residue.

This unit is moderately suited to homesite development. The main limitation is the depth to bedrock, which makes excavation difficult.

Septic tank absorption fields will not filter effluent properly. If the density of housing is moderate to high, community sewage systems are needed to prevent contamination of water supplies as a result of seepage from onsite sewage disposal systems.

This unit is suited to recreational development. Plant cover can be maintained by limiting traffic.

The use of this unit as wildlife habitat and watershed can be enhanced by maintaining the forest cover. The unit is a major source of recharge for the northern aquifer.

This unit is moderately suited to grazing. The main limitation is the very low available water capacity. The quality of tropical forage is extremely low if it is allowed to mature. Livestock rotation improves the quality of forage. The quality of forage can also be improved by introducing adapted grasses and legumes. Yield can be increased by fertilizing. Practices such as salting, constructing livestock watering facilities, fencing, mowing or dragging, and protecting the unit from fire can be used to enhance the carrying capacity of the soil.

This map unit is in capability subclass IVs.

26—Guam cobbly clay loam, 7 to 15 percent slopes. This very shallow, well drained soil is on limestone plateaus. It formed in sediment over porous coralline limestone. Slopes are long and plane. The vegetation in areas not cultivated is mainly forest. Elevation is 30 to 200 meters.

Typically, 5 to 10 percent of the surface is covered with gravel and cobbles. The surface layer is dark reddish brown cobbly clay loam about 5 centimeters thick. The subsoil is dusky red gravelly clay loam about 15 centimeters thick. Coralline limestone is at a depth of 20 centimeters. Depth to limestone ranges from 5 to 41 centimeters. In some places, a thin layer of soft, fractured limestone is below the subsoil. The deeper areas commonly are nongravelly, and the shallower areas commonly are very gravelly. The soil is neutral to mildly alkaline.

Included in this unit are small areas of coral Rock outcrop and Ritidian soils that commonly are on shoulder

slopes and short, moderately steep slopes. Also included are small areas of Yigo soils at the base of slopes and nearly level to gently sloping Guam soils. Limestone quarries are in some areas. Included areas make up about 10 percent of the total hectarage.

Permeability of this Guam soil is moderately rapid. Available water capacity is very low. Effective rooting depth is 5 to 41 centimeters. Roots enter the limestone along cracks and pores. Runoff is slow, and the hazard of water erosion is moderate.

This unit is used as watershed and wildlife habitat. It can be used for commercial and subsistence farming, grazing, and homesite and recreational development.

The use of this unit as wildlife habitat and watershed can be enhanced by maintaining the forest cover.

This unit is poorly suited to subsistence farming. The main limitations are the very shallow soil depth, droughtiness, and the hazard of erosion. Banana, tangerine, and other fruit trees should be planted only in the deeper areas. In most areas the bedrock should be excavated to a depth of at least 50 centimeters and the area backfilled with soil before planting trees. Irrigation is needed for vegetables. Growth and production of fruit trees can be increased by irrigating during the dry season. Clean cultivation should be avoided. Weeds can be controlled by mulching and mowing. Compost can be applied to improve soil fertility.

This unit is poorly suited to commercial production of vegetables, and it is not suited to commercial production of fruit. The main limitations are the very shallow soil depth, droughtiness, the hazard of erosion, and cobbles. With proper management, most vegetables can be grown throughout the year. Irrigation is required throughout the year for commercial production. Drip irrigation is suited to this unit. Light, frequent applications of irrigation water are needed. Windbreaks are needed for the production of crops. All tillage should be across the slope. Erosion can be reduced by avoiding clean cultivation, by installing grassed waterways, diversion, or terraces, and by planting cover crops. Crops respond to fertilizer. Foliar applications of micronutrients improve yields of many crops. The organic matter content can be maintained by rotating crops and by plowing under cover crops and all crop residue.

This unit is moderately suited to grazing. The main limitation is the very low available water capacity. The quality of tropical forage is extremely low if it is allowed to mature. Livestock rotation improves the quality of forage and helps to prevent erosion caused by overstocking and trailing. The quality of forage can be improved by introducing adapted grasses and legumes. Yield can be increased by fertilizing. Practices such as salting, constructing livestock watering facilities, fencing, mowing or dragging, and protecting the unit from fire can be used to enhance the carrying capacity of the soil and to prevent erosion.

This unit is poorly suited to homesite development. The main limitations are the depth to bedrock and slope. Excavation is difficult because of the depth to bedrock. The cuts needed to provide level building sites will expose bedrock. Preserving the existing plant cover during construction and revegetating disturbed areas around construction sites as soon as possible help to control erosion. Topsoil can be stockpiled and used to reclaim areas disturbed during construction.

Septic tank absorption fields will not filter effluent properly. If the density of housing is moderate to high, community sewage systems are needed to prevent contamination of water supplies as a result of seepage from onsite sewage disposal systems.

This unit is suited to recreational development. Plant cover can be maintained by limiting traffic. Playgrounds, ball fields, and other recreation areas that require level sites are difficult to establish on this unit.

This map unit is in capability subclass IVs.

27—Guam-Saipan complex, 0 to 7 percent slopes. This map unit is on limestone plateaus. Slopes are undulating. The vegetation is mainly forest. Elevation is 30 to 200 meters.

This unit is 60 percent Guam cobbly clay loam and 30 percent Saipan silty clay. The Guam soil is in higher lying convex areas and on upper side slopes, and the Saipan soil is in concave depressional areas and on lower side slopes. The components of this unit are so intricately intermingled that it was not practical to map them separately.

The Guam soil is very shallow and well drained. It formed in sediment overlying porous coralline limestone. Typically, the surface layer is dark reddish brown cobbly clay loam about 5 centimeters thick. The subsoil is dusky red gravelly clay loam about 15 centimeters thick. Some areas are dominantly 25 to 41 centimeters deep and are nongravelly. The soil is neutral to mildly alkaline.

Permeability of this Guam soil is moderately rapid. Available water capacity is very low. Effective rooting depth is 5 to 41 centimeters. The limestone is permeable and can be penetrated by roots along the many clay-filled cracks and pores. Runoff is slow, and the hazard of water erosion is slight.

The Saipan soil is deep and very deep and is well drained. It formed in sediment overlying limestone. Typically, the surface layer is dark reddish brown silty clay about 15 centimeters thick. The subsoil to a depth of 140 centimeters or more is yellowish red and red clay. Depth to limestone ranges from 100 to 150 centimeters or more. The soil is neutral.

Permeability of this Saipan soil is moderate. Effective rooting depth is 100 to 150 centimeters or more. Available water capacity is moderate. Runoff is medium, and the hazard of water erosion is slight. Brief periods of ponding occur following high-intensity rains.

Included in this unit are small areas of Kagman, Pulantat, and Yigo soils, soils that are 50 to 100 centimeters deep to limestone, and Rock outcrop in higher lying areas and on shoulder slopes. Also included are small areas of soils that have slopes of more than 7 percent. Included areas make up about 10 percent of the total hectarage.

This unit is used for commercial and subsistence farming, grazing, homesites, wildlife habitat, and watershed. It can be used for recreational development.

This unit is moderately suited to subsistence farming. The main limitation is the very low available water capacity of the Guam soil. Where possible, areas of the Saipan soil should be used for crops rather than areas of the Guam soil. During the dry season, irrigation is needed for shallow-rooted vegetables. Growth and production of banana, papaya, and other fruit trees can be increased by irrigating during the dry season. Compost can be applied to improve soil fertility.

This unit is moderately suited to commercial production of vegetables, and it is poorly suited to commercial production of fruit. It is limited by the very shallow depth, droughtiness, and cobbles in the Guam soil. With proper management, most vegetables can be grown throughout the year. Irrigation is required throughout the year for commercial crop production. Drip irrigation is suited to this unit. Light, frequent applications of irrigation water are needed. Windbreaks are needed for the production of crops. In some areas excessive cobbles must be removed. Crops respond to fertilizer. Foliar application of nutrients improves yields of many crops. The organic matter content can be maintained by rotating crops and by plowing under cover crops and all crop residue.

This unit is moderately suited to grazing. The main limitation is the very low available water capacity. Livestock rotation improves the quality of forage and helps to prevent erosion caused by overstocking and trailing. Introducing adapted grasses and legumes improves the quality of forage. Yield can be increased by applying fertilizer. Production of tangantangan can be improved by cutting them at a suitable height for grazing. Practices such as salting, constructing livestock watering facilities, fencing, mowing or dragging, and protecting the unit from fire can be used to enhance the carrying capacity of the soil.

This unit is moderately suited to homesite development. The main limitation of the Guam soil is the shallow depth to bedrock, which interferes with excavation. The main limitation of the Saipan soil is the low soil strength. The cuts needed to provide level building sites on the Guam soil will expose bedrock. The main limitations for roads are the depth to bedrock in the Guam soil and low strength of the Saipan soil. The load bearing capacity of the Saipan soil can be improved by spreading gravel fill before constructing buildings and roads. Topsoil can be stockpiled and used to reclaim areas disturbed during construction. Preserving the existing plant cover during construction and revegetating disturbed areas around construction sites as soon as possible help to control soil erosion.

Septic tank absorption fields should be installed in areas of the Saipan soil rather than in areas of the Guam soil, which will not filter effluent properly. If the density of housing is moderate to high, community sewage systems are needed to prevent contamination of water supplies as a result of seepage from onsite sewage disposal systems.

The use of this unit as wildlife habitat and watershed can be enhanced by maintaining the forest cover.

The main limitations of this unit for recreational development are occasional stones on the surface of the Guam soil, the included areas of Rock outcrop, and the clayey texture of the Saipan soil. Plant cover can be maintained by limiting traffic.

The Guam soil is in capability subclass IVs. The Saipan soil is in capability subclass IIe.

28—Guam-Urban land complex, 0 to 3 percent slopes. This unit is on limestone plateaus. Most areas have been disturbed by land shaping for urban development. Many areas are covered by roads, buildings, parking lots, and airstrips. Elevation is 30 to 200 meters.

This unit is about 55 percent Guam cobbly clay loam and 45 percent Urban land. The percentage varies from one area to another.

The Guam cobbly clay loam is very shallow and well drained. It formed in sediment overlying porous coralline limestone. Typically, the surface layer has been removed or mixed with the underlying material during construction. The subsoil is dusky red cobbly clay loam about 15 centimeters thick over porous coralline limestone. Depth to limestone commonly is 5 to 25 centimeters; however, because of cutting, filling, and leveling, limestone is at the surface in some places. The soil is neutral to mildly alkaline.

Permeability of this Guam soil is moderately rapid. Available water capacity is very low. Runoff is slow, and the hazard of water erosion is slight.

Urban land consists of areas covered with roads, buildings, parking lots, and airstrips. Most of these structures were built directly on the underlying coral bedrock or on a pad of coral gravel.

Included in this unit are a few limestone gravel quarries.

This unit is used as homesites, as commercial and industrial sites, and for other urban uses.

The main limitation of this unit for homesite development is the very shallow depth of the Guam soil, which makes excavation difficult. Community sewage systems are needed to prevent contamination of water supplies as a result of seepage. Irrigation and fertilizer are necessary for the establishment of lawns and

landscaping plants. Before planting trees and shrubs, the bedrock should be excavated to a depth of at least 50 centimeters and the area backfilled with soil.

The Guam soil is in capability subclass IVs.

29—Guam-Yigo complex, 0 to 7 percent slopes. This map unit is on plateaus. Slopes are concave. Areas commonly are elongated. The vegetation in areas not cultivated is mainly forest. Elevation is 30 to 200 meters.

This unit is 55 percent Guam cobbly clay loam and 40 percent Yigo silty clay. The Guam soil is on side slopes and in higher lying areas, and the Yigo soil is in depressional areas. The components of this unit are so intricately intermingled that it was not practical to map them separately.

The Guam soil is very shallow and well drained. It formed in sediment overlying porous coralline limestone. Typically, 5 to 10 percent of the surface is covered with gravel and cobbles. The surface layer is dark reddish brown cobbly clay loam about 5 centimeters thick. The subsoil is dusky red gravelly clay loam about 15 centimeters thick. Limestone is at a depth of 20 centimeters. Depth to limestone ranges from 5 to 41 centimeters. In some places, a thin layer of soft, fractured limestone is below the subsoil. The deeper areas commonly are nongravelly, and the shallower areas commonly are very gravelly. The soil is neutral to mildly alkaline.

Permeability of this Guam soil is moderately rapid. Available water capacity is very low. Effective rooting depth is 5 to 41 centimeters. Roots enter the limestone along cracks, fissures, and pores. Runoff is slow, and the hazard of water erosion is slight.

The Yigo soil is deep and well drained. It formed in sediment derived dominantly from coralline limestone. Typically, the surface layer is dark reddish brown silty clay about 15 centimeters thick. The subsoil is dusky red and dark red silty clay about 135 centimeters thick. Depth to limestone ranges from 102 to 150 inches or more. The surface layer is slightly acid, and the subsoil is neutral.

Permeability of this Yigo soil is moderate. Available water capacity is low. Effective rooting depth is 102 to 150 centimeters or more. Runoff is slow, and the erosion hazard is slight.

Included in this unit are small areas of moderately deep soils and shallow, nongravelly soils. Included areas make up less than 5 percent of the total hectarage.

This unit is used for commercial and subsistence farming (fig. 7), wildlife habitat, and watershed. It can be used for grazing and for homesite and recreational development.

This unit is moderately suited to subsistence farming. The main limitations of the Guam soil are the very shallow depth and very low available water capacity. The main limitations of the Yigo soil are the low available water capacity and low soil fertility. Banana, tangerine, and other fruit trees should be planted in areas of the Yigo soil. To provide calcium, some coral gravel from the Guam soil should be mixed into the areas of the Yigo soil that are used for planting. Irrigation is needed for vegetables grown on the Guam soil year-round. Irrigation is needed only during the dry season for crops grown on the Yigo soil. Compost can be applied to improve soil fertility.

This unit is moderately suited to commercial production of vegetables, and it is poorly suited to commercial production of fruit. It is limited by the very shallow depth, the content of cobbles, and the very low available water capacity of the Guam soil. With proper management, most vegetables can be grown throughout the year. Irrigation is required throughout the year for commercial crop production. Drip irrigation is suited to this unit. Light, frequent applications of irrigation water are needed. Windbreaks are needed for the production of crops. In some areas, excessive cobbles must be removed. Crops respond to fertilizer. Foliar application of nutrients improves yields of many crops. The organic matter content can be maintained by rotating crops and by plowing under cover crops and all crop residue.

The use of this unit as wildlife habitat and watershed can be enhanced by maintaining the forest cover.

This unit is moderately suited to grazing. The main limitation is the very low available water capacity of the Guam soil. Forage can be improved by introducing adapted grasses and legumes. Yield can be increased by applying fertilizer. Practices such as salting, constructing livestock watering facilities, fencing, mowing or dragging, and protecting the unit from fire can be used to enhance the carrying capacity of the soil.

This unit is moderately suited to homesite development. The main limitation of the Guam soil is the depth to bedrock, which makes excavation difficult. The main limitation of the Yigo soil is low soil strength. The load bearing capacity of the Yigo soil can be improved by spreading gravel fill before constructing buildings and roads. Topsoil can be stockpiled and used to reclaim areas disturbed during construction.

Septic tank absorption fields should be installed in areas of the Yigo soil rather than in areas of the Guam soil, which will not filter effluent properly. If the density of housing is moderate to high, community sewage systems are needed to prevent contamination of water supplies as a result of seepage from onsite sewage disposal systems.

This unit is suited to recreational development. Plant cover can be maintained by limiting traffic.

The Guam soil is in capability subclass IVs, and the Yigo soil is in capability subclass IIs.

30—Inarajan clay, 0 to 4 percent slopes. This deep and very deep, poorly drained soil is on broad valley bottoms. It formed in alluvium derived dominantly from volcanic rock and limestone. Slopes are long and plane.

Figure 7.—Area of Guam-Yigo complex, 0 to 7 percent slopes. Bell peppers are on the Guam soil, and bananas are on the Yigo soil.

In many areas not cultivated, the surface is hummocky. The vegetation in areas not cultivated is mainly wetland forest or grasses and sedges. Elevation is sea level to 100 meters.

Typically, the surface layer is dark gray clay about 25 centimeters thick. The underlying material to a depth of more than 150 centimeters is variegated, mottled clay. Colors include dark yellowish brown, yellowish brown, gray, yellowish red, reddish yellow, and light olive brown. The surface layer is strongly acid to neutral, and the underlying material is medium acid to neutral.

Included in this unit are small areas of Inarajan Variant soils in depressional areas and Ylig soils and well drained soils on natural levees along riverbanks. Also included are small areas of gently sloping, well drained upland colluvial soils along valley edges, a few short, steep escarpments along riverbanks and channels, and soils that are moderately deep to bedrock. An extensive area around Achang Bay, near Merizo, is underlain by limestone at a depth of 50 to 102 centimeters. Included areas make up about 5 percent of the total hectarage.

Permeability of this Inarajan soil is slow. Available water capacity is high. Runoff is very slow to ponded, and the hazard of water erosion is slight. A seasonal high water table fluctuates between depths of 51 and 102 centimeters during the rainy season, and it gradually recedes during the dry season. This soil is subject to brief periods of flooding during the rainy season. Surface cracks extend to a depth of about 51 centimeters during the dry season.

This unit is used for commercial and subsistence farming during the dry season (fig. 8). It is also used for

grazing, homesites, aquaculture, watershed, and wildlife habitat. It can be used for recreational development.

This unit is moderately suited to subsistence farming. The main limitations are wetness during the rainy season and lack of water late in the dry season. The unit is well suited to taro and other crops that tolerate seasonal wetness. Most vegetables cannot be grown during the rainy season. Banana, tangerine, and other fruit trees can be grown only on the natural levees along the rivers and on the colluvial valley edges. During the dry season, irrigation is needed for shallow-rooted vegetables. Growth and production of banana, papaya, and and other fruit trees can be increased by irrigating during the dry season. Compost can be applied to improve soil fertility.

This unit is moderately suited to commercial farming. Vegetables such as beans, Chinese and head cabbages, and cucumbers and watermelons and cantaloupes can only be grown in the dry season. Most areas of this unit are poorly suited to banana and other fruit trees that are sensitive to wetness. In most areas, artificial drainage is necessary for commercial production of fruit. Farming is not feasible on this unit during the rainy season. Field operations should be avoided after heavy rains. Using raised beds for crops helps to overcome the problem of wetness. Ditches or a subsurface drainage system can be used to remove excess water if a suitable outlet is available. During the dry season, irrigation is needed for maximum production of row crops. Drip irrigation is suited to this unit. Crops respond to fertilizer.

Figure 8.—Watermelons, bananas, and other crops in an area of Inarajan clay, 0 to 4 percent slopes.

This unit is moderately suited to grazing. The main limitation is wetness during the rainy season. Grazing when the soil is wet results in compaction of the surface layer. Practices such as salting, constructing livestock watering facilities, fencing, mowing or dragging, and protecting the unit from fire can be used to enhance the carrying capacity of the soil.

This unit is poorly suited to homesite development. The main limitations are occasional flooding and the seasonal high water table. Drainage is needed if roads and buildings are constructed. Foundation drains and proper grading help to overcome wetness problems for new homes. Dikes and channels that have outlets for floodwater can be used to protect buildings and onsite sewage disposal systems from flooding. The main limitations for roads are low soil strength and flooding. Roads and streets should be located above the expected flood level. The load bearing capacity of the soil can be improved by spreading gravel fill before constructing buildings and roads. Septic tank absorption fields do not function properly because of the seasonal high water table.

The main limitation for aquaculture is the hazard of flooding during prolonged, high-intensity storms. Dikes around ponds should be high enough to protect them from floodwater.

The use of this unit as wildlife habitat and watershed can be enhanced by preserving the plant cover and protecting seasonal ponds from pollutants. Practices that increase the duration of ponding while preserving the surrounding vegetation enhance the habitat. Such practices include pond development, restricting drainage, and directing runoff and drainage water into the ponds.

The main limitations for recreational development are wetness and the clayey texture of the soil. Plant cover can be maintained by limiting traffic. Drainage should be provided for paths and trails.

This map unit is in capability subclass IIw.

31—Inarajan sandy clay loam, 0 to 3 percent slopes. This deep, somewhat poorly drained soil is on narrow coastal plains. It formed in alluvium derived dominantly from volcanic rock, limestone, and beach deposits. Areas are long and narrow. The vegetation in areas not cultivated is mainly grasses, forbs, and forest. Elevation is sea level to 100 meters.

Typically, the surface layer is dark grayish brown sandy clay loam about 20 centimeters thick. The underlying material to a depth of more than 150 centimeters is stratified, mottled sand, clay, sandy clay loam, and sandy loam. The sandy strata are white, and the clayey strata are dark gray. The soil is mildly alkaline to moderately alkaline.

Included in this unit are small areas of Inarajan clay, sandy soils adjacent to the beach, and soils underlain by limestone between depths of 50 and 102 centimeters. Also included are small areas of Ylig soils and well drained soils that commonly are in gently sloping areas, loamy soils adjacent to uplands, and Inarajan Variant soils in depressional areas and bordering swamps. Included areas make up about 15 percent of the total hectarage.

Permeability of this Inarajan soil is slow. Available water capacity is high. Runoff is slow, and the hazard of water erosion is slight. A seasonal high water table fluctuates between depths of 51 and 102 centimeters during the rainy season, and it gradually recedes during the dry season. This soil is subject to brief periods of flooding during the rainy season.

This unit is used for subsistence and commercial farming, grazing, homesites, watershed, and wildlife habitat. It can be used for recreational development.

This unit is moderately suited to subsistence farming. The main limitations are wetness during the rainy season and droughtiness late in the dry season. The unit is well suited to taro and other crops that tolerate seasonal wetness. Most vegetables cannot be grown during the rainy season. The unit is poorly suited to fruit trees. Bananas can be grown only in some better drained areas. During the dry season, irrigation is needed for shallow-rooted vegetables. Compost can be applied to improve soil fertility.

This unit is moderately suited to commercial farming. The main limitations are the high water table during the rainy season and droughtiness late in the dry season. Vegetables such as beans, Chinese and head cabbages, cucumbers, watermelons, and cantaloupes can be grown in the dry season. The unit is poorly suited to tree crops. A few areas where drainage is better are suited to this use. Farming is not feasible on this unit during the rainy season. Using raised beds for crops helps to overcome the problem of wetness. Ditches or a subsurface drainage system can be used to remove excess water if a suitable outlet is available. Irrigation is required for maximum production of row crops during the dry season. Drip irrigation is suited to this unit. The organic matter content can be maintained by rotating crops and by plowing under cover crops and all crop residue. Crops respond to fertilizer.

This unit is moderately suited to grazing. The main limitations are wetness in the rainy season. Grazing when the soil is wet results in compaction of the surface layer. Practices such as salting, constructing livestock watering facilities, fencing, mowing or dragging, and protecting the unit from fire can be used to enhance the carrying capacity of the soil. The production of forage from tangantangan trees can be improved by cutting them at a suitable height for grazing.

This unit is poorly suited to homesite development. The main limitations are occasional flooding and a seasonal high water table. Drainage is needed if roads and buildings are constructed. Foundation drains and proper grading help to overcome wetness problems for new homes. Dikes and channels that have outlets for

floodwater can be used to protect buildings and onsite sewage disposal systems from flooding. The main limitations for roads are low soil strength and flooding. Roads and streets should be located above the expected flood level. The load bearing capacity of the soil can be improved by spreading gravel fill before constructing buildings and roads. Septic tank absorption fields do not function properly because of the seasonal high water table.

The use of this unit as wildlife habitat and watershed can be enhanced by maintaining the forest cover.

The main limitation of this unit for recreational development is seasonal wetness. Plant cover can be maintained by limiting traffic. Drainage should be provided for paths and trails.

This unit is poorly suited to aquaculture. The main limitation is the sandy texture of the soil, which results in seepage from ponds.

This map unit is in capability subclass IIw.

32—Inarajan Variant mucky clay, 0 to 3 percent slopes. This very deep, very poorly drained soil is on valley bottoms and coastal plains. The surface is hummocky in many areas. It formed in alluvium derived from mixed sources. The native vegetation is mainly wetland grasses and sedges or mangrove forest. Elevation is sea level to 100 meters.

Typically, the surface layer is black and dark grayish brown mucky clay about 5 centimeters thick. The substratum to a depth of 130 centimeters is dominantly dark gray and dark greenish gray clay with strong brown mottles. The next 20 centimeters is black and dark brown organic material. Below this to a depth of 160 centimeters or more is dark bluish gray mucky sandy loam. The soil is neutral to medium acid.

Included in this unit are small areas of Inarajan soils near valley heads, soils that have thick organic layers, and soils that are underlain with sand or coral bedrock and are near the coast. Also included are small areas of soils on short, steep streambanks. Included areas make up about 10 percent of the total hectarage.

Permeability of this Inarajan Variant soil is moderately slow. Available water capacity is very high. Runoff is very slow to ponded, and the hazard of water erosion is slight. A permanent high water table fluctuates from 50 centimeters above the surface to a depth of about 60 centimeters below the surface. This soil is subject to short periods of flooding during the rainy season, and it is ponded for long periods. Many areas are affected by saline ground water.

This unit is used as watershed and wildlife habitat. It is not suited to subsistence or commercial farming, grazing, or homesite or recreational development. The main limitation is the permanent high water table.

The use of this unit as wildlife habitat and watershed can be enhanced by maintaining the native vegetation. Practices that increase the duration of ponding while preserving the surrounding vegetation enhance the habitat. Such practices include pond development, restricting pond drainage, and directing runoff and drainage water into ponded areas.

This map unit is in capability subclass VIIw.

33—Pulantat clay, 3 to 7 percent slopes. This shallow, well drained soil is on limestone plateaus. It formed in residuum derived dominantly from argillaceous limestone. Slopes are undulating. The vegetation is mainly tangantangan forest and grasses. Elevation is 5 to 100 meters.

Typically, the surface layer is black and very dark grayish brown silty clay and clay about 18 centimeters thick. The subsoil is brown clay about 12 centimeters thick. Weathered limestone is at a depth of 30 centimeters. Depth to weathered limestone ranges from 25 to 51 centimeters. The surface layer is slightly acid to neutral, and the subsoil is mildly alkaline.

Included in this unit are small areas of Chacha and Saipan soils in depressional areas and soils that are 51 to 100 centimeters deep to limestone. Also included are small areas of Rock outcrop, soils that are very shallow and very gravelly and are in high-lying areas and on shoulder slopes, soils that are level, and soils that have short, moderately steep slopes. Included areas make up about 10 percent of the total hectarage.

Permeability of this Pulantat soil is slow. Available water capacity is very low. Effective rooting depth is about 25 to 51 centimeters. Roots can penetrate the limestone along the many clay-filled fissures and pores. Runoff is medium, and the hazard of water erosion is slight.

This unit is used mainly as homesites, wildlife habitat, and watershed. It is also used for subsistence and commercial farming and grazing. The unit can be used for recreational development.

This unit is moderately suited to homesite development. The main limitation is the shallow depth to limestone, which interferes with excavation. The cuts needed to provide level building sites will expose limestone. Topsoil can be stockpiled and used to reclaim areas disturbed during construction. Preserving the existing plant cover during construction helps to control erosion. Revegetating disturbed areas around construction sites as soon as possible helps to control soil erosion. Septic tank absorption fields will not filter effluent properly. If the density of housing is moderate to high, community sewage systems are needed to prevent contamination of water supplies as a result of seepage from onsite sewage disposal systems.

The use of this unit as wildlife habitat and watershed can be enhanced by maintaining the forest cover.

This unit is moderately suited to subsistence farming. The main limitations are the shallow soil depth, the very low available water capacity, and the susceptibility of the soil to compaction when it is moist. The unit is poorly

suited to fruit trees, which should be planted in the deeper areas where possible. In the shallower areas, the cobbly limestone should be excavated or loosened with a pick to a depth of at least 50 centimeters. During the dry season, irrigation is needed for shallow-rooted vegetables. Growth and production of banana, papaya, and other fruit trees can be increased by irrigating during the dry season. Mechanical tillage and vehicle traffic should be avoided when the soil is wet. Clean cultivation should be avoided. Weeds can be controlled by mulching and mowing. Compost can be applied to improve soil fertility.

This unit is moderately suited to most commercial farming. The main limitations are the shallow soil depth, very low available water capacity, and the susceptibility of the soil to compaction when it is moist. This unit is poorly suited to fruit trees. Before planting banana, papaya, citrus, or other fruit trees, the soil should be ripped to a depth of at least 50 centimeters to allow roots to penetrate into the argillaceous limestone. Cobbles and stones on the surface and the included areas of Rock outcrop interfere with tillage operations. During the dry season, irrigation is required for maximum production of row crops. Drip irrigation is suited to this unit. Light, frequent applications of irrigation water are needed. Field operations should be avoided after heavy rains. All tillage should be across the slope. Erosion can be prevented by installing diversions, terraces, or grassed waterways, mulching, and planting cover crops. The organic matter content can be maintained by rotating crops and by plowing under cover crops and all crop residue. Crops respond to fertilizer. Windbreaks are needed for the production of crops.

This unit is moderately suited to grazing. The main limitation is the very low available water capacity of the soil. The production of forage from tangantangan trees can be improved by cutting them at a suitable height for grazing. Practices such as salting, constructing livestock watering facilities, fencing, mowing or dragging, and protecting the unit from fire can be used to enhance the carrying capacity of the soil.

The main limitation of this unit for recreational development is occasional stones on the surface and the included areas of Rock outcrop. Plant cover can be maintained by limiting traffic.

This map unit is in capability subclass IVs.

34—Pulantat clay, 7 to 15 percent slopes. This shallow, well drained soil is on limestone plateaus and hills. It formed in residuum derived dominantly from argillaceous limestone. Slopes are convex and rolling. The vegetation is mainly tangantangan forest and grasses. Elevation is 5 to 100 meters.

Typically, the surface layer is black and very dark grayish brown silty clay and clay about 18 centimeters thick. The subsoil is brown clay about 12 centimeters thick. Weathered limestone is at a depth of 30 centimeters. Depth to limestone ranges from 25 to 51 inches. Gravel and cobbles are on the surface in some areas. The surface layer is slightly acid to neutral, and the subsoil is mildly alkaline.

Included in this unit are small areas of Chacha, Kagman, and Saipan soils in depressional areas and soils that are 51 to 100 centimeters deep to limestone. Also included are small areas of Rock outcrop, soils that are very shallow and very gravelly and are in high-lying areas and on shoulder slopes, soils that are gently sloping, and soils that have short, moderately steep slopes. Included areas make up about 10 percent of the total hectarage.

Permeability of this Pulantat soil is slow. Available water capacity is very low. Effective rooting depth is 25 to 51 centimeters. Roots can penetrate the limestone along the many clay-filled fissures and pores. Runoff is medium, and the hazard of water erosion is moderate.

This unit is used as homesites, wildlife habitat, and watershed. It can be used for grazing, subsistence and commercial farming, and recreational development.

This unit is moderately suited to homesite development. The main limitation is the shallow depth to limestone, which interferes with excavation. The cuts needed to provide level building sites will expose limestone. Topsoil can be stockpiled and used to reclaim areas disturbed during construction. Preserving the existing plant cover during construction and revegetating disturbed areas around construction sites as soon as possible help to control soil erosion. The main limitations for roads are the depth to bedrock, a high shrink-swell potential, and low soil strength. The load bearing capacity of the soil can be improved by spreading gravel fill before constructing buildings or roads.

Septic tank absorption fields will not filter effluent properly. If the density of housing is moderate to high, community sewage systems are needed to prevent contamination of water supplies as a result of seepage from onsite sewage disposal systems.

The use of this unit as wildlife habitat and watershed can be enhanced by maintaining the forest cover.

This unit is moderately suited to grazing. The main limitation is the very low available water capacity. The quality of tropical forage is extremely low if it is allowed to mature. Livestock rotation improves the quality of forage and helps to prevent erosion caused by overstocking and trailing. The quality of forage also can be improved by introducing adapted grasses and legumes. Yield can be increased by fertilizing. Practices such as salting, constructing livestock watering facilities, fencing, mowing or dragging, and protecting the unit from fire can be used to enhance the carrying capacity of the soil and to prevent erosion.

This unit is moderately suited to subsistence farming. The main limitations are shallow soil depth, the hazard of erosion, the very low available water capacity, and the susceptibility of the soil to compaction when it is moist.

The unit is poorly suited to fruit trees. Banana, tangerine, and other fruit trees should be planted in the deeper areas where possible. In the shallower areas, the limestone should be excavated or loosened with a pick to a depth of at least 50 centimeters. Clean cultivation should be avoided. Weeds can be controlled by mulching and mowing. During the dry season, irrigation is needed for shallow-rooted vegetables. Growth and production of banana, papaya, and other fruit trees can be increased by irrigating during the dry season. Mechanical tillage and vehicle traffic should be avoided when the soil is wet. Compost can be applied to improve soil fertility.

This unit is moderately suited to commercial farming. The main limitations are shallow soil depth, the hazard of erosion, very low available water capacity, and the susceptibility of the soil to compaction when it is moist. The unit is poorly suited to fruit trees. Before planting banana, papaya, citrus, or other fruit trees, the soil should be ripped to a depth of at least 50 centimeters to allow roots to penetrate into the argillaceous limestone. Cobbles and stones on the surface and the included areas of Rock outcrop interfere with tillage operations. All tillage should be across the slope. Erosion can be reduced by installing diversions, terraces, or grassed waterways and by planting cover crops. During the dry season, irrigation is required for maximum production of row crops. Drip irrigation is suited to this unit. Light, frequent applications of irrigation water are needed. Field operations should be avoided after heavy rains. The organic matter content can be maintained by rotating crops and by plowing under cover crops and all crop residue. Crops respond to fertilizer. Windbreaks are needed for the production of crops.

The main limitations of this unit for recreational development are the hazard of erosion, occasional stones on the surface, and the included areas of Rock outcrop. Plant cover can be maintained by limiting traffic. Playgrounds, ball fields, and other recreation areas that require level slopes are difficult to establish in this unit.

This map unit is in capability subclass IVs.

35—Pulantat clay, 15 to 30 percent slopes. This shallow, well drained soil is on dissected plateaus and hills. It formed in residuum derived dominantly from argillaceous limestone. Slopes are plane to convex. The vegetation is mainly tangantangan forest. Elevation is 5 to 100 meters.

Typically, the surface layer is black and very dark grayish brown silty clay and clay about 18 centimeters thick. The subsoil is brown clay about 12 centimeters thick. Weathered limestone is at a depth of 30 centimeters. Depth to limestone ranges from 25 to 51 centimeters. Gravel and cobbles are on the surface in some areas. The surface layer is slightly acid to neutral, and the subsoil is mildly alkaline.

Included in this unit are small areas of Rock outcrop and soils that are very shallow and very gravelly and are on hilltops and shoulder slopes. Also included are small areas of soils that are 51 to 100 centimeters deep to limestone and are on lower slopes, in depressional areas, and on benches. These areas generally have slopes of less than 15 percent. Included areas make up about 10 percent of the total hectarage.

Permeability of this Pulantat soil is slow. Available water capacity is very low. Effective rooting depth is about 25 to 51 centimeters. Roots can penetrate the limestone along the many clay-filled fissures and pores. Runoff is medium, and the hazard of water erosion is severe.

This unit is used as wildlife habitat and watershed. It can be used for grazing, subsistence farming, and homesite and recreational development. It is not suited to commercial farming. A few small areas of this unit that are on gently sloping benches and lower side slopes can be farmed.

The use of this unit as wildlife habitat and watershed can be enhanced by maintaining the forest cover.

This unit is moderately suited to grazing. The main limitations are slope, gully erosion caused by continuous grazing, and the very low available water capacity. The quality of tropical forage is extremely low if it is allowed to mature. Livestock rotation improves the quality of forage and helps to prevent erosion caused by overstocking and trailing. The quality of forage can be improved by introducing adapted grasses and legumes. Yield can be increased by fertilizing. Practices such as salting, constructing livestock watering facilities, fencing, mowing or dragging, and protecting the unit from fire can be used to enhance the carrying capacity of the soil and to prevent erosion.

This unit is poorly suited to subsistence farming. The main limitations are the hazard of erosion, shallow soil depth, and very low available water capacity. Banana, tangerine, and other fruit trees should be planted in the deeper areas whenever possible. In the shallower areas, the limestone should be excavated or loosened with a pick to a depth of at least 50 centimeters. Clean cultivation should be avoided. Weeds can be controlled by mulching and mowing. During the dry season, irrigation is needed for shallow-rooted vegetables. Growth and production of banana, papaya, and other fruit trees can be increased by irrigating during the dry season. Compost can be applied to improve soil fertility.

This unit is poorly suited to homesite development. The main limitations are the steepness of slope, the hazard of erosion, and depth to bedrock. Slopes are too steep for conventional construction techniques. Only isolated ridgelines and hilltops can be used as construction sites. The cuts needed to provide level building sites will expose the limestone. Topsoil can be stockpiled and used to reclaim areas disturbed during construction. Preserving the existing plant cover during

construction helps to control erosion. Revegetating disturbed areas around construction sites as soon as possible helps to control soil erosion.

Septic tank absorption fields will not filter effluent properly. Slope is a concern in installing septic tank absorption fields. Absorption lines should be installed on the contour. Specialized designs are needed to overcome the limitation of slope.

Slope limits the recreational use of this unit mainly to a few paths and trails, which should extend across the slope and along ridgelines. Plant cover can be maintained by limiting traffic.

This map unit is in capability subclass VIe.

36—Pulantat clay, 30 to 60 percent slopes. This shallow, well drained soil is on dissected plateaus and hills. It formed in residuum and colluvium derived dominantly from argillaceous limestone. Slopes are plane. The vegetation is mainly tangantangan forest. Elevation is 5 to 100 meters.

Typically, the surface layer is black and very dark grayish brown silty clay and clay about 18 centimeters thick. The subsoil is brown clay about 12 centimeters thick. Weathered limestone is at a depth of 30 centimeters. Depth to limestone ranges from 25 to 51 centimeters. Gravel and cobbles are on the surface in some areas. The surface layer is slightly acid to neutral, and the subsoil is mildly alkaline.

Included in the unit are small areas of Rock outcrop and soils that are very shallow and very gravelly and are on ridgelines and shoulder slopes. Also included are small areas of colluvial soils that are 51 to 100 centimeters deep to limestone and are on lower slopes and benches and in drainageways. These areas generally have slopes of less than 30 percent. Included areas make up about 10 percent of the total hectarage.

Permeability of this Pulantat soil is slow. Available water capacity is very low. Effective rooting depth is about 25 to 51 centimeters. Roots can penetrate the limestone along the many clay-filled fissures and pores. Runoff is rapid, and the hazard of water erosion is very severe.

This unit is used as wildlife habitat and watershed. It can be used for recreational development. It is not suited to grazing, commercial or subsistence farming, or homesite development.

The use of this unit as wildlife habitat and watershed can be enhanced by maintaining the forest cover.

Slope limits the recreational use of this unit mainly to a few paths and trails, which should extend across the slope and along ridgelines. Plant cover can be maintained by limiting traffic.

This map unit is in capability subclass VIIe.

37—Pulantat-Chacha clays, undulating. This map unit is on upland limestone plateaus. Slopes are moderately short and undulating. The vegetation in areas not cultivated is mainly grasses and tangantangan forest. Elevation is 60 to 100 meters.

This unit is 60 percent Pulantat clay and 35 percent Chacha clay. The Pulantat soil is in broad high-lying areas and on upper slopes. It has slopes of mainly 3 to 7 percent. The Chacha soil is in broad depressional areas and on lower slopes. It has slopes of mainly 0 to 5 percent. The components of this unit are so intricately intermingled that it was not practical to map them separately.

The Pulantat soil is shallow and well drained. It formed in residuum derived dominantly from argillaceous limestone. Typically, the surface layer is black and very dark grayish brown silty clay and clay about 18 centimeters thick. The subsoil is brown clay about 12 centimeters thick. Weathered limestone is at a depth of 30 centimeters. Depth to limestone ranges from 25 to 51 centimeters. The surface layer is slightly acid to neutral, and the subsoil is mildly alkaline.

Permeability of this Pulantat soil is slow. Available water capacity is very low. Effective rooting depth is 25 to 51 centimeters. Roots can penetrate the limestone along the many clay-filled fissures and pores. Runoff is medium, and the hazard of water erosion is slight.

The Chacha soil is very deep and somewhat poorly drained. It formed in sediment derived dominantly from argillaceous limestone and volcanic saprolite. Typically, the surface layer is dark brown clay about 20 centimeters thick. The subsoil to a depth of 109 centimeters is dominantly strong brown clay. The surface layer and subsoil have many black manganese concretions. The substratum to a depth of more than 150 centimeters is mixed strong brown, red, and white, highly weathered saprolite. Depth to saprolite ranges from 102 to 150 centimeters or more. The surface layer is medium acid, and the subsoil is neutral to mildly alkaline.

Permeability of this Chacha soil is slow. Available water capacity is moderate. Effective rooting depth is 150 centimeters or more. Runoff is ponded to very slow, and the hazard of water erosion is slight. This soil is saturated for significant periods of time during the rainy season as a result of an intermittent perched water table. Ponding can occur in level areas following high rainfall storms.

Included in this unit are small areas of limestone Rock outcrop on shoulder slopes, soils that are moderately deep to limestone, and Kagman soils. Also included are small areas of soils that have slopes of more than 7 percent and soils that are less than 25 centimeters deep to limestone. Included areas make up about 5 percent of the total hectarage.

This unit is used mainly for commercial and subsistence farming and as homesites. It is also used as wildlife habitat and watershed. It can be used for grazing and recreational development.

The unit is moderately suited to subsistence farming. The main limitations of the Pulantat soil are shallow soil depth and very low available water capacity. The main limitations of the Chacha soil are wetness during the rainy season and droughtiness late in the dry season. Both soils are limited by a susceptibility to compaction when they are moist. Banana, papaya, citrus, and other fruit trees should be planted in the deeper areas of the Pulantat soil and well above the low, ponded areas of the Chacha soil. Wetness of the Chacha soil can be reduced by using raised beds for crop production. Ditches can be used to remove excess water if a suitable outlet is available. Rainy season cropping may not be feasible in the lower areas of the Chacha soil. The Chacha soil is better suited to cropping during the dry season than is the Pulantat soil, but irrigation is needed for shallow-rooted vegetables. Growth and production of banana, papaya, and other fruit trees can be increased by irrigating during the dry season. Mechanical tillage and vehicle traffic should be avoided when the soil is wet. Clean cultivation should be avoided. Weeds can be controlled by mulching and mowing. Compost can be applied to improve soil fertility.

This unit is moderately suited to commercial farming. It is poorly suited to fruit trees. The main limitations are the seasonal perched water table in the Chacha soil, the shallow depth and droughtiness of the Pulantat soil, and the susceptibility of the soils to compaction when wet. Production of fruit and vegetables during the rainy season is feasible only if artificial drainage is provided for areas of the Chacha soil. Surface ditches or a subsurface drainage system can be used to lower the water table if a suitable outlet is available. Irrigation is required for crop production. Drip irrigation is suited to this unit. Light, frequent applications of irrigation water are needed. Soil compaction can be minimized by avoiding field operations after heavy rains. All tillage should be across the slope. Erosion can be reduced by avoiding clean cultivation, by installing grassed waterways, diversions, or terraces, and by planting cover crops. The organic matter content can be maintained by rotating crops and by plowing under cover crops and all crop residue. Crops respond to fertilizer. Windbreaks are needed for the production of crops.

This unit is poorly suited to homesite development. The main limitation of the Pulantat soil is the shallow depth to limestone, which interferes with excavation. The cuts needed to provide level building sites on the Pulantat soil will expose bedrock. The main limitation of the Chacha soil is wetness during the rainy season. The main limitations for roads are depth to bedrock and low strength of the Pulantat soil and wetness and high shrink-swell potential of the Chacha soil. The load bearing capacity of the soil can be improved by spreading gravel fill before constructing buildings or roads. Cutbanks are not stable and are subject to slumping. Excess water can be removed by using suitably designed drainage ditches. Use of foundation drains and proper grading help to prevent wetness problems for new homes. Topsoil can be stockpiled and used to reclaim areas disturbed during construction. Preserving the existing plant cover during construction and revegetating disturbed areas around construction sites as soon as possible help to control soil erosion.

Septic tank absorption fields do not function properly on this unit because of the seasonal perched water table in the Chacha soil and the shallow depth to bedrock in the Pulantat soil. If the density of housing is moderate to high, community sewage systems are needed to prevent contamination of water supplies as a result of seepage from onsite sewage disposal systems.

The use of this unit as wildlife habitat and watershed can be enhanced by maintaining the forest cover. Low-lying areas of the Chacha soil that are ponded in the rainy season provide habitat for the Mariana gallinule and other wildlife species.

This unit is moderately suited to grazing. The main limitations are the very low available water capacity of the Pulantat soil and the susceptibility of the Chacha soil to compaction during the rainy season. Livestock should be removed when the Chacha soil is ponded. Rotating livestock and introducing adapted grasses and legumes improve the quality of forage. Practices such as salting, constructing livestock watering facilities, fencing, mowing or dragging, and protecting the unit from fire can be used to enhance the carrying capacity of the soils. The production of forage from tangantangan trees can be improved by cutting them at a suitable height for grazing.

The main limitations of this unit for recreational development are the clayey soil texture and wetness of the Chacha soil during the rainy season. Paths and trails should extend across the slope and along ridgelines. Plant cover can be maintained by limiting traffic.

The Pulantat soil is in capability subclass IVs, and the Chacha soil is in capability subclass IIIw.

38—Pulantat-Chacha clays, rolling. This map unit is on plateaus. Slopes are short. The vegetation is mainly tangantangan forest and grasses. Elevation is 60 to 100 meters.

This unit is 60 percent Pulantat clay and 35 percent Chacha clay. The Pulantat soil is on broad ridgelines and upper slopes. Slopes are mainly 7 to 15 percent. The Chacha soil is in broad depressional areas and on lower slopes. Slopes are mainly 3 to 7 percent. The components of this unit are so intricately intermingled that it was not practical to map them separately.

The Pulantat soil is shallow and well drained. It formed in residuum derived dominantly from argillaceous limestone. Typically, the surface layer is black and very dark grayish brown silty clay and clay about 18 centimeters thick. The subsoil is brown clay about 12 centimeters thick. Weathered limestone is at a depth of 30 centimeters. Depth to limestone ranges from 25 to 51

centimeters. The surface layer is slightly acid to neutral, and the subsoil is mildly alkaline.

Permeability of this Pulantat soil is slow. Available water capacity is very low. Effective rooting depth is 25 to 51 centimeters. Runoff is medium, and the hazard of water erosion is moderate.

The Chacha soil is very deep and somewhat poorly drained. It formed in sediment derived dominantly from argillaceous limestone and volcanic saprolite. Typically, the surface layer is dark brown clay about 20 centimeters thick. The subsoil to a depth of about 109 centimeters is dominantly strong brown clay. The surface layer and subsoil have many black manganese concretions. The substratum to a depth of 150 centimeters or more is mixed strong brown, red, and white, highly weathered saprolite. Depth to saprolite ranges from 102 to 150 centimeters or more. The surface layer is medium acid, and the subsoil is neutral to mildly alkaline.

Permeability of this Chacha soil is slow. Available water capacity is moderate. Effective rooting depth is 150 centimeters. Runoff is slow, and the hazard of water erosion is slight. This soil is saturated for significant periods of time during the rainy season as a result of an intermittent perched water table.

Included in this unit are small areas of limestone Rock outcrop and very shallow soils on ridges and shoulder slopes, moderately deep soils, Kagman soils, and Chacha Variant soils in depressional areas. Also included are small areas of soils that have moderately steep slopes and soils that are level to nearly level. Ponding can occur in the level areas following storms accompanied by high rainfall. Included areas make up about 5 percent of the total hectarage.

This unit is used mainly for commercial and subsistence farming, grazing, and homesites. It is also used as wildlife habitat and watershed. The unit can be used for recreational development.

This unit is moderately suited to subsistence farming. The main limitations of the Pulantat soil are the shallow depth, the hazard of erosion, and the very low available water capacity. The main limitations of the Chacha soil are wetness during the rainy season and droughtiness late in the dry season. Both soils are limited by susceptibility to compaction when they are moist. Banana, papaya, citrus, and other fruit trees should be planted in the deeper areas of the Pulantat soil and well above the low lying areas of the Chacha soil. Wetness of the Chacha soil can be reduced by using raised beds for crop production. Ditches can be used to remove excess water if a suitable outlet is available. Rainy season cropping may not be feasible in the lower areas of the Chacha soil. During the dry season, the Chacha soil is better suited to cropping than is the Pulantat soil. Clean cultivation should be avoided. Weeds can be controlled by mulching and mowing. During the dry season, irrigation is needed for shallow-rooted vegetables. Growth and production of banana, papaya, and other fruit trees can be increased by irrigating during the dry season. Mechanical tillage and vehicle traffic should be avoided when the soil is wet. Compost can be applied to improve soil fertility.

This unit is moderately suited to commercial farming and poorly suited to fruit trees. The main limitations are the seasonal perched water table in the Chacha soil, the shallow depth, the hazard of erosion, the droughtiness of the Pulantat soil, and the susceptibility of the soils to compaction when they are moist. Production of fruit and vegetables during the rainy season is feasible only if artificial drainage is provided. Surface ditches or a subsurface drainage system can be used to lower the water table if a suitable outlet is available. Irrigation is required for crop production. Drip irrigation is suited to this unit. Light, frequent applications of irrigation water are needed. All tillage should be across the slope. Erosion can be reduced by avoiding clean cultivation, by installing grassed waterways, diversions, or terraces, and by planting cover crops. The organic matter content can be maintained by rotating crops and by plowing under cover crops and all crop residue. Soil compaction can be minimized by avoiding field operations after heavy rains. Crops respond to fertilizer. Windbreaks are needed for the production of crops.

This unit is moderately suited to grazing. The main limitations are the very low available water capacity in the Pulantat soil and the susceptibility of the Chacha soil to compaction during the rainy season. Livestock should be removed when the Chacha soil is wet. Livestock rotation improves the quality of forage and helps to prevent erosion caused by overstocking and trailing. Yield can be increased by fertilizing. Practices such as salting, constructing livestock watering facilities, fencing, mowing or dragging, and protecting the unit from fire can be used to enhance the carrying capacity of the soil and to prevent erosion. The production of forage from tangantangan trees can be improved by cutting them at a suitable height for grazing.

This unit is poorly suited to homesite development. The main limitation of the Pulantat soil is the shallow depth to limestone, which interferes with excavation. The cuts needed to provide level building sites will expose bedrock. The main limitation of the Chacha soil is wetness during the rainy season. The main limitations for roads are depth to bedrock, high shrink-swell potential, and low soil strength. The load bearing capacity can be improved by spreading gravel fill before constructing buildings or roads. Cutbanks are not stable and are subject to slumping. Excess water can be removed by using suitably designed drainage ditches. Use of foundation drains and proper grading help to overcome wetness problems for new homes. Revegetating disturbed areas around construction sites as soon as possible helps to control soil erosion.

Septic tank absorption fields do not function properly on this unit because of the depth to bedrock in the Pulantat soil and the seasonal perched water table in the Chacha soil. If the density of housing is moderate to high, community sewage systems are needed to prevent contamination of water supplies as a result of seepage from onsite sewage disposal systems.

The use of this unit as wildlife habitat and watershed can be enhanced by maintaining the forest cover. The low-lying areas of the included soils that are ponded during the rainy season provide habitat for the Mariana gallinule and other wildlife species.

The main limitations of this unit for recreational development are the clayey soil texture, wetness during the rainy season, and the hazard of erosion. Drainage should be provided for paths and trails. Paths and trails should extend across the slope and along the ridgelines. Plant cover can be maintained by limiting traffic.

The Pulantat soil is in capability subclass IVs, and the Chacha soil is in capability subclass IIIw.

39—Pulantat-Kagman clays, 0 to 7 percent slopes. This map unit is on limestone plateaus. Slopes are undulating. The vegetation in areas not cultivated is mainly tangantangan forest and grasses. Elevation is 3 to 200 meters.

This unit is 60 percent Pulantat clay and 30 percent Kagman clay. The Pulantat soils are in higher lying, convex areas and on upper side slopes, and the Kagman soils are in concave depressional areas and on lower side slopes. The components of this unit are so intricately intermingled that it was not practical to map them separately.

The Pulantat soil is shallow and well drained. It formed in residuum derived dominantly from argillaceous limestone. Typically, the surface layer is black and very dark grayish brown silty clay and clay about 18 centimeters thick. The subsoil is brown clay about 12 centimeters thick. Weathered limestone is at a depth of 30 centimeters. Depth to limestone ranges from 25 to 51 centimeters. The surface layer is slightly acid to neutral, and the subsoil is mildly alkaline.

Permeability of this Pulantat soil is slow. Available water capacity is very low. Effective rooting depth is about 25 to 51 centimeters. Roots can penetrate the limestone along the many clay-filled fissures and pores. Runoff is medium, and the hazard of water erosion is slight.

The Kagman soil is deep and very deep and is well drained. It formed in residuum and alluvium derived dominantly from argillaceous limestone. Typically, the surface layer is very dark grayish brown to dark brown clay about 16 centimeters thick. The subsoil to a depth of 150 centimeters or more is strong brown, yellowish red, and red clay. White argillaceous limestone is at a depth of 150 centimeters or more. The soil is slightly acid to neutral.

Permeability of this Kagman soil is moderately slow. Available water capacity is moderate. Effective rooting depth is 150 centimeters or more. Runoff is medium, and the hazard of water erosion is slight. Brief periods of ponding occur following high-intensity rains.

Included in this unit are small areas of Chacha soils in depressional areas and very shallow, very gravelly soils in high-lying areas and on shoulder slopes. Also included are small areas of Rock outcrop, Guam and Saipan soils, and soils that have short, steep slopes. Included areas make up about 10 percent of the total hectarage.

This unit is used for commercial and subsistence farming, homesites, recreational development, watershed, and wildlife habitat. It can be used for grazing.

The Pulantat soil is moderately suited to subsistence farming. The main limitations are the shallow depth and very low available water capacity. The Kagman soil is well suited to subsistence farming. The main limitation is droughtiness late in the dry season. Both soils are limited by susceptibility to compaction when they are wet. Wherever feasible, areas of the Kagman soil should be used for crops rather than areas of the Pulantat soil. During the dry season, irrigation is needed for shallow-rooted vegetables. Growth and production of banana, papaya, and other fruit trees can be increased by irrigating during the dry season. Mechanical tillage and vehicle traffic should be avoided when the soil is wet. Clean cultivation should be avoided. Weeds can be controlled by mulching and mowing. Compost can be applied to improve soil fertility.

This unit is moderately suited to commercial farming. The main limitations are the shallow depth and very low available water capacity of the Pulantat soil, wetness of the Kagman soil during the rainy season, and the susceptibility of the soils to compaction when they are moist. This unit is poorly suited to fruit trees. Before planting fruit trees, the Pulantat soil should be ripped to a depth of at least 50 centimeters to allow roots to penetrate the limestone. Irrigation is required for crop production. Drip irrigation is suited to this unit. Light, frequent applications of irrigation water are needed. Ditches or a subsurface drainage system can be used to remove excess water from the Kagman soil during the rainy season. An erosion control system that includes use of diversions, terraces, hillside ditches, and grassed waterways may be needed. The organic matter content can be maintained by rotating crops and by plowing under cover crops and all crop residue. Crops respond to fertilizer. Windbreaks are needed for production of crops.

This unit is moderately suited to homesite development. The main limitation of the Pulantat soil is the shallow depth to limestone, which interferes with excavation. The main limitations of the Kagman soil are the high shrink-swell potential and low soil strength. The cuts needed to provide level building sites on the

Pulantat soil will expose limestone. The main limitations for roads are depth to bedrock, the high shrink-swell potential, and low soil strength. The effects of shrinking and swelling can be minimized by using proper engineering designs and by removing the soil and backfilling with suitable material. The load bearing capacity of the soil can be improved by spreading gravel fill before constructing buildings or roads. Cutbanks are not stable and are subject to slumping. Topsoil can be stockpiled and used to reclaim areas disturbed during construction. Preserving the existing plant cover during construction and revegetating disturbed areas around construction sites as soon as possible help to control soil erosion.

Septic tank absorption fields will not filter effluent properly in the Pulantat soil because of the depth to bedrock. If the Kagman soil is used for septic tank absorption fields, the limitation of moderately slow permeability can be overcome by increasing the size of the absorption field. If the density of housing is moderate to high, community sewage systems are needed to prevent contamination of water supplies as a result of seepage from onsite sewage disposal systems.

The main limitations of this unit for recreational development are the shallow depth and occasional stones on the surface of the Pulantat soil, the included areas of Rock outcrop, and the clayey texture of the soils. Plant cover can be maintained by limiting traffic.

The use of this unit as wildlife habitat and watershed can be enhanced by maintaining the forest cover.

This unit is moderately suited to grazing. The main limitations are the very low available water capacity of the Pulantat soil and the susceptibility of the soils to compaction when they are moist. The production of forage from tangantangan trees can be improved by cutting them at a suitable height for grazing. Livestock rotation improves the quality of forage and helps to prevent erosion caused by overstocking and trailing. Forage can be improved by introducing adapted grasses and legumes. Yield can be increased by fertilizing. Practices such as salting, constructing livestock watering facilities, fencing, mowing or dragging, and protecting the unit from fire can be used to enhance the carrying capacity of the soil.

The Pulantat soil is in capability subclass IVs, and the Kagman soil is in capability subclass IIe.

40—Pulantat-Kagman clays, 7 to 15 percent slopes. This map unit is on plateaus. Slopes are short and rolling. The vegetation in areas not cultivated is mainly tangantangan forest and grasses. Elevation is 3 to 200 meters.

This unit is 60 percent Pulantat clay and 30 percent Kagman clay. The Pulantat soil is in higher lying, convex areas and on upper side slopes. The Kagman soil is in concave depressional areas and on lower lying side slopes. The components of this unit are so intricately intermingled that it was not practical to map them separately.

The Pulantat soil is shallow and well drained. It formed in residuum derived dominantly from argillaceous limestone. Typically, the surface layer is black and very dark grayish brown silty clay and clay about 18 centimeters thick. The subsoil is brown clay about 12 centimeters thick. Weathered limestone is at a depth of 30 centimeters. The surface layer is slightly acid to neutral, and the subsoil is mildly alkaline.

Permeability of this Pulantat soil is slow. Available water capacity is very low. Effective rooting depth is 25 to 51 centimeters. Roots can penetrate the limestone along the many clay-filled fissures and pores. Runoff is medium, and the hazard of water erosion is moderate.

The Kagman soil is deep and very deep and is well drained. It formed in residuum and alluvium derived dominantly from argillaceous limestone. Typically, the surface layer is dark brown clay about 14 centimeters thick. The subsoil to a depth of 150 centimeters is strong brown yellowish red and red clay. White argillaceous limestone is at a depth of 150 centimeters. The soil is slightly acid to neutral.

Permeability of this Kagman soil is moderately slow. Effective rooting depth is 150 centimeters or more. Available water capacity is moderate. Runoff is medium, and the hazard of water erosion is moderate. Brief periods of ponding occur in depressional areas following high-intensity rains.

Included in this unit are small areas of Chacha soils in depressional areas, soils that are deeper or shallower to bedrock, and very gravelly, very shallow soils in high-lying areas and on shoulder slopes. Also included are small areas of Rock outcrop, Guam and Saipan soils, soils that have short, steep slopes, and soils that are nearly level. Included areas make up about 10 percent of the total hectarage.

This unit is used for commercial and subsistence farming, grazing, homesites, recreational development, watershed, and wildlife habitat.

This unit is moderately suited to subsistence farming. The main limitations are the shallow depth and very low available water capacity of the Pulantat soil, the hazard of erosion, and the susceptibility of the soils to compaction when they are moist. This unit is poorly suited to fruit trees. Wherever feasible, areas of the Kagman soil should be used for crops rather than areas of the Pulantat soil. Clean cultivation should be avoided. Weeds can be controlled by mulching and mowing. During the dry season, irrigation is needed for shallow-rooted vegetables. Growth and production of banana, papaya, and other fruit trees can be increased by irrigating during the dry season. Mechanical tillage and vehicle traffic should be avoided when the soil is wet. Compost can be applied to improve soil fertility.

This unit is poorly suited to commercial farming. The main limitations are the shallow depth and very low

available water capacity of the Pulantat soil, wetness of the Kagman soil during the rainy season, the hazard of erosion, and the susceptibility of the soils to compaction when they are moist. Before planting fruit trees, the Pulantat soil should be ripped to a depth of at least 50 centimeters to allow roots to penetrate the limestone. Irrigation is required for crop production. Drip irrigation is suited to this unit. Light, frequent applications of irrigation water are needed. Ditches or a subsurface drainage system can be used to remove excess water from the Kagman soil during the rainy season. Soil compaction can be minimized by avoiding field operations after heavy rains. An erosion control system that includes use of diversions, terraces, hillside ditches, and grassed waterways may be needed. The organic matter content can be maintained by using all crop residue, plowing under cover crops, and using a suitable rotation. Crops respond to fertilizer. Windbreaks are needed for the production of crops on the unit.

This unit is moderately suited to grazing. The main limitations are the very low available water capacity of the Pulantat soil and the susceptibility of the soils to compaction when they are moist. The quality of tropical forage is extremely low if it is allowed to mature. Livestock rotation improves the quality of forage and helps to prevent erosion caused by overstocking and trailing. The quality of forage can also be improved by introducing adapted grasses and legumes. Yield can be increased by fertilizing. Restricting grazing during wet periods helps to keep the pasture in good condition. Practices such as salting, constructing livestock watering facilities, fencing, mowing or dragging, and protecting the unit from fire can be used to enhance the carrying capacity of the soil and to prevent erosion. The production of forage from tangantangan trees can be improved by cutting them at a suitable height for grazing.

This unit is moderately suited to homesite development. The main limitation of the Pulantat soil is the shallow depth to limestone, which interferes with excavation. The cuts needed to provide level building sites will expose limestone. The main limitations of the Kagman soil are high shrink-swell potential and low soil strength. The main limitations for roads are depth to bedrock, high shrink-swell potential, and low soil strength. The load bearing capacity of the soil can be improved by spreading gravel fill before constructing buildings or roads. Topsoil can be stockpiled and used to reclaim areas disturbed during construction. Preserving the existing plant cover during construction and revegetating disturbed areas around construction sites as soon as possible help to control soil erosion.

Septic tank absorption fields will not filter effluent properly on the Pulantat soil because of the depth to bedrock. If the Kagman soil is used for septic tank absorption fields, the limitation of moderately slow permeability can be overcome by increasing the size of the absorption field. Slope is a concern in installing septic tank absorption fields. Absorption lines should be installed on the contour. If the density of housing is moderate to high, community sewage systems are needed to prevent contamination of water supplies as a result of seepage from onsite sewage disposal systems.

The main limitations of this unit for recreational development are the depth to bedrock and occasional stones on the surface of the Pulantat soil, the included areas of Rock outcrop, and the clayey texture of the soils. Plant cover can be maintained by limiting traffic.

The use of this unit as wildlife habitat and watershed can be enhanced by maintaining the forest cover.

The Pulantat soil is in capability subclass IVs, and the Kagman soil is in capability subclass IIIe.

41—Pulantat-Urban land complex, 0 to 7 percent slopes. This map unit is on upland limestone plateaus. Slopes are level in areas shaped by construction activity and are short and undulating in the undisturbed areas. Elevation is 5 to 100 meters.

This unit is 50 percent Pulantat clay and 45 percent Urban land. The components of this unit are so intricately intermingled that it was not practical to map them separately.

The Pulantat soil is shallow and well drained. It formed in residuum derived dominantly from argillaceous limestone. Typically, the surface layer is black and very dark grayish brown silty clay and clay about 18 centimeters thick. The subsoil is brown clay about 12 centimeters thick. Weathered limestone is at a depth of 30 centimeters. Depth to limestone ranges from 25 to 51 centimeters. The surface layer is slightly acid to neutral, and the subsoil is mildly alkaline. In some areas the surface layer has been removed or mixed with the subsoil during construction.

Permeability of this Pulantat soil is slow. Available water capacity is very low. Effective rooting depth is about 25 to 51 centimeters. Roots can penetrate the limestone along the many clay-filled fissures and pores. Runoff is medium, and the hazard of water erosion is slight.

Urban land consists of areas covered by buildings, roads, and parking lots. Some of these areas have a base of crushed coral, and some rest directly on limestone.

Included in this unit are small areas of limestone Rock outcrop and short, steep cutbanks that were exposed during construction. Also included are small areas of moderately sloping Pulantat soils and areas, such as in ball fields and home gardens, where additional topsoil has been added. Extensive areas of Kagman and Chacha soils are in some villages, mainly Talofofo and Barrigada. Included areas make up about 5 percent of the total hectarage.

This unit is used for subsistence farming, and for homesite development and other urban uses.

This unit is poorly suited to subsistence farming. The main limitations are the extensive areas of gravelly, compacted fill material, shallow soil depth, and droughtiness during the dry season. Before planting trees or shrubs, the soil should be excavated or loosened with a pick to a depth of at least 50 centimeters. During the dry season, irrigation is needed for shallow-rooted vegetables. Growth and production of banana, papaya, and other fruit trees can be increased by irrigating during the dry season. Compost can be applied to improve soil fertility.

This unit is moderately suited to homesite development. The main limitations are the shallow depth to limestone, which interferes with excavation, and a high shrink-swell potential. The cuts needed to provide level building sites will expose limestone. Topsoil can be stockpiled and used to reclaim areas disturbed during construction. Preserving the existing plant cover and revegetating disturbed areas around construction sites as soon as possible help to control soil erosion.

Septic tank absorption fields on this unit will not filter effluent properly. Community sewage systems are needed to prevent contamination of water supplies as a result of seepage from onsite sewage disposal systems.

Mulch, fertilizer, and irrigation are needed to establish lawn grasses and other small-seeded plants. For best results, pebbles and cobbles should be removed from the surface before lawns are established.

If this unit is used for recreational development, the main limitations are occasional stones on the surface of the soil and the included areas of Rock outcrop. Plant cover can be maintained by limiting traffic.

The Pulantat soil is in capability subclass IVs.

42—Pulantat-Urban land complex, 7 to 15 percent slopes. This map unit is on plateaus. Large areas have been disturbed by land shaping for urban development. Slopes are short and undulating in undisturbed areas. Elevation is 5 to 100 meters.

This unit is 70 percent Pulantat clay and 30 percent Urban land. The Pulantat clay is on side slopes, and the Urban land is on broad hilltops and ridgelines. The components of this unit are so intricately intermingled that it was not practical to map them separately.

The Pulantat soil is shallow and well drained. It formed in residuum derived dominantly from argillaceous limestone. Typically, the surface layer is black and very dark grayish brown silty clay and clay about 18 centimeters thick. The subsoil is brown very gravelly clay 12 centimeters thick. Weathered limestone is at a depth of 30 centimeters. Depth to limestone ranges from 25 to 51 centimeters. The surface layer is slightly acid to neutral, and the subsoil is mildly alkaline. In some areas the surface layer has been removed or mixed with the subsoil during construction.

Permeability of this Pulantat soil is slow. Roots can penetrate the limestone along the many clay-filled fissures and pores. Available water capacity is very low. Effective rooting depth is 25 to 51 centimeters. Runoff is medium, and the hazard of water erosion is moderate.

Urban land consists of areas covered by buildings, roads, and parking lots. Some of these areas have a base of crushed coral and some rest directly on limestone.

Included in this unit are small areas of limestone Rock outcrop and short, steep cutbanks that were exposed during construction. Also included are small areas of nearly level or steep Pulantat soils, Chacha soils in depressional areas, and areas, such as in ball fields and home gardens, where additional topsoil has been added.

This unit is used for subsistence farming, homesite development, and wildlife habitat. It can be used for recreational development and home gardening. It is not suited to commercial farming or grazing.

This unit is poorly suited to subsistence farming. The main limitations are the areas of gravelly, compacted fill material, shallow soil depth, the hazard of erosion, and droughtiness during the dry season. Before planting trees or shrubs, the soil should be excavated or loosened with a pick to a depth of at least 50 centimeters. Clean cultivation should be avoided. Weeds can be controlled by mulching and mowing. During the dry season, irrigation is needed for shallow-rooted vegetables. Growth and production of banana, papaya, and other fruit trees can be increased by irrigating during the dry season.

This unit is moderately suited to homesite development. The main limitations are the shallow depth to limestone, which interferes with excavation, the high shrink-swell potential, and slope. The cuts needed to provide level building sites will expose limestone. The effects of shrinking and swelling can be minimized by using proper engineering designs and by removing the soil and backfilling with suitable material. Topsoil can be stockpiled and used to reclaim areas disturbed during construction. Preserving the existing plant cover during construction and revegetating disturbed areas around construction sites as soon as possible help to control soil erosion.

Septic tank absorption fields do not filter effluent properly. Community sewage systems are needed to prevent contamination of water supplies as a result of seepage from onsite sewage disposal systems.

Mulch, fertilizer, and irrigation are needed to establish lawn grasses and other small-seeded plants. For best results, pebbles and cobbles should be removed from the surface before lawns are established.

The use of this unit as wildlife habitat and watershed can be enhanced by maintaining forest cover in areas too steep or isolated to urbanize.

The main limitations for recreational development are occasional stones on the surface and the included areas of Rock outcrop. Plant cover can be maintained by limiting traffic.

The Pulantat soil is in capability subclass IVe.

43—Ritidian-Rock outcrop complex, 3 to 15 percent slopes. This map unit is on plateaus and escarpments (fig. 9). Slopes are short and irregular. The vegetation is mainly forest. Elevation is sea level to 400 meters.

This unit is 45 percent Ritidian extremely cobbly clay loam and 35 percent Rock outcrop. The Ritidian soil is in small pockets that are intricately intermingled with Rock outcrop.

The Ritidian soil is very shallow and well drained. It formed in residuum derived dominantly from coralline limestone. Typically, 60 to 90 percent of the surface is covered with gravel, cobbles, and stones. The soil is dark reddish brown extremely cobbly clay loam 10 centimeters thick over porous coral limestone. Depth to limestone ranges from 5 to 25 centimeters. The soil is mildly alkaline to moderately alkaline.

Permeability of this Ritidian soil is moderately rapid. Available water capacity is very low. Effective rooting depth is 5 to 25 centimeters. Runoff is very slow, and the hazard of water erosion is slight.

The Rock outcrop is exposed areas of white, porous coralline limestone. The surface is jagged and irregular. Organic debris, soil material, and roots are in the cracks and interstices. Permeability is rapid, and runoff is very slow.

Included in this unit is about 10 percent Guam cobbly clay loam. Also included is about 10 percent Rock outcrop on steep escarpments, Ritidian soils that are nearly level, and limestone quarries.

This unit is used as wildlife habitat and watershed. It can be used for recreational development. It is not suited to subsistence or commercial farming, grazing, or homesite development. The main limitation is the areas of jagged, uneven, limestone Rock outcrop.

The use of this unit as wildlife habitat and watershed can be enhanced by maintaining the native forest cover.

If this unit is used for recreational development, the main limitation is the areas of Rock outcrop. Use is limited to a few paths and trails.

The Ritidian soil is in capability subclass VIIs, and the Rock outcrop is in capability subclass VIIIs.

Figure 9.—Area of Ritidian-Rock outcrop complex, 3 to 15 percent slopes.

44—Ritidian-Rock outcrop complex, 15 to 60 percent slopes. This map unit is on dissected limestone plateaus and escarpments. Slopes are dominantly long and plane. Occasional benches and vertical cliffs are present. Areas are irregular or elongated in shape. The vegetation is mainly forest. Elevation is sea level to 400 meters.

This unit is 50 percent Ritidian extremely cobbly clay loam and 45 percent Rock outcrop. The Ritidian soil is in small pockets that are intricately intermingled with Rock outcrop.

The Ritidian soil is very shallow and well drained. It formed in residuum derived dominantly from coralline limestone. Typically, 60 to 90 percent of the surface is covered with gravel, cobbles, and stones. The soil is dark reddish brown extremely cobbly clay loam 10 centimeters thick over porous coral limestone. Depth to limestone ranges from 5 to 25 centimeters. The soil is mildly alkaline to moderately alkaline.

Permeability of this Ritidian soil is moderately rapid. Available water capacity is very low. Effective rooting depth is 5 to 25 centimeters. Runoff is very slow, and the hazard of water erosion is slight.

The Rock outcrop is exposed areas of white, porous coralline limestone. The surface is jagged and irregular. Organic debris, soil material, and roots are in cracks and interstices. Permeability is rapid, and runoff is very slow.

Included in this unit are small areas of nearly vertical limestone cliffs and areas where slopes are less than 15 percent. Also included are small areas of Guam cobbly clay loam. Included areas make up about 5 percent of the total hectarage.

This unit is used as wildlife habitat and watershed. It can be used for recreational development. It is not suited to subsistence or commercial farming, grazing, or homesite development. The main limitations are slope and the areas of jagged, uneven limestone Rock outcrop.

The use of this unit as wildlife habitat and watershed can be enhanced by maintaining the native forest cover. Clifflines in this unit provide important habitat for various birds and the Marianas fruit bat.

Slope limits the recreational use of this unit mainly to a few paths and trails.

The Ritidian soil is in capability subclass VIIs, and the Rock outcrop is in capability subclass VIIIs.

45—Rock outcrop-Ritidian complex, 60 to 99 percent slopes. This map unit is on limestone escarpments. It is characterized by vertical cliffs and occasional ledges and benches. Areas are narrow and elongated in shape. The vegetation is mainly forest along the benches and ledges. The cliff faces are nearly barren. Elevation is sea level to 400 meters.

This unit is 50 percent Rock outcrop and 45 percent Ritidian extremely cobbly clay loam. The Ritidian soil is intricately intermingled with Rock outcrop, but it occurs mostly on ledges and benches.

The Rock outcrop is exposed areas of white, porous coralline limestone. It is mainly on nearly vertical cliff faces that commonly are smooth and barren of vegetation. In vegetated areas, the surface is jagged and irregular. Organic debris, soil material, and roots are in cracks and interstices. Permeability is rapid, and runoff is slow.

The Ritidian soil is very shallow and well drained. It formed in residuum derived dominantly from coralline limestone. Typically, 60 to 90 percent of the surface is covered with gravel, cobbles, and stones. The soil is dark reddish brown extremely cobbly clay loam 10 centimeters thick over porous coral limestone. Depth to limestone ranges from 5 to 25 centimeters. The soil is mildly alkaline to moderately alkaline.

Permeability of this Ritidian soil is moderately rapid. Available water capacity is very low. Effective rooting depth is 5 to 25 centimeters. Runoff is very slow, and the hazard of water erosion is slight.

Included in this unit are small areas of soils at the top of cliffs that have slopes of less than 60 percent. Also included are small areas of Guam and Pulantat soils. Included areas make up about 5 percent of the total hectarage.

This unit is suited only to use as wildlife habitat and watershed. It is limited by the steepness of slope and the areas of jagged, uneven limestone Rock outcrop.

The use of this unit as wildlife habitat and watershed can be enhanced by maintaining the native forest cover. Clifflines in this unit provide important habitat for various birds and for the Marianas fruit bat.

This map unit is in capability subclass VIIIs.

46—Sasalaguan clay, 7 to 15 percent slopes. This deep, well drained soil is on volcanic uplands. It formed in residuum derived dominantly from marine-deposited tuffaceous sandstone. Slopes are broad and are plane to slightly concave. The vegetation in areas not cultivated is mainly grasses. Elevation is 9 to 200 meters.

Typically, the surface layer is dominantly dark brown clay about 13 centimeters thick. The subsoil is dominantly dark red and brown clay about 58 centimeters thick. The substratum to a depth of more than 150 centimeters is dominantly red, light yellowish brown, and very pale brown saprolite that crushes to clay or clay loam. Depth to saprolite ranges from 51 to 102 centimeters. The soil is strongly acid to slightly acid.

Included in this unit are small areas of Akina and Agfayan soils and Ylig soils in drainageways and depressional areas. Also included are small areas of soils that have short, steep slopes and soils that are nearly level and are on ridgelines and benches. Included areas make up about 10 percent of the total hectarage.

Permeability of this Sasalaguan soil is slow. Available water capacity is moderate. Effective rooting depth is

100 to 150 centimeters. Runoff is medium, and the hazard of water erosion is moderate. Surface cracks extend into the underlying saprolite during the dry season.

This unit is used mainly for subsistence and commercial farming, grazing, watershed, and wildlife habitat. It is also used for homesite development. It can be used for recreational development.

This unit is moderately suited to subsistence farming. The main limitations are the hazard of erosion, low soil fertility, the susceptibility of the soil to compaction when it is moist, and droughtiness late in the dry season. Clean cultivation should be avoided. Weeds can be controlled by mulching and mowing. Compost can be applied to improve soil fertility. During the dry season, irrigation is needed for shallow-rooted vegetables. Growth and production of banana, papaya, and other fruit trees can be increased by irrigating during the dry season.

This unit is moderately suited to commercial farming. Crops that can be grown are those adapted to clayey soils, including watermelons, head and Chinese cabbages, and fruit trees. The main limitations are the hazard of erosion, the susceptibility of the soil to compaction when it is moist, and droughtiness late in the dry season. All tillage should be across the slope. Erosion can be reduced by avoiding clean cultivation, by installing grassed waterways, diversions, or terraces, and by mulching or planting cover crops. Crops respond to fertilizer and lime. The organic matter content can be maintained by rotating crops and by plowing under cover crops and all crop residue. Field operations should be avoided after heavy rains. During the dry season, irrigation is required for maximum production of crops. Drip irrigation is suited to this unit. Windbreaks are needed for the production of crops.

This unit is well suited to grazing. The quality of tropical forage is extremely low if it is allowed to mature. Livestock rotation improves the quality of forage and helps to prevent erosion caused by overstocking and trailing. The quality of forage can be improved by introducing adapted grasses and legumes. Yield can be increased by fertilizing and liming. Restricting grazing during wet periods helps to keep the pasture in good condition. Practices such as salting, constructing livestock watering facilities, fencing, mowing or dragging, and protecting the unit from fire can be used to enhance the carrying capacity of the soil and to prevent erosion.

The use of this unit as wildlife habitat and watershed can be enhanced by protecting the unit from wildfires and by planting adapted trees. Establishing firebreaks and restricting public access can help to prevent wildfires. Prescribed burning of adjacent cropland should be closely supervised. Forest cover improves the watershed by reducing surface runoff and erosion. It also provides valuable cover for wildlife.

This unit is poorly suited to homesite development. The main limitation is the high shrink-swell potential. The effects of shrinking and swelling can be minimized by using proper engineering designs and by removing the soil and backfilling with suitable material. Preserving the existing plant cover during construction and revegetating disturbed areas around construction sites as soon as possible help to control soil erosion. Topsoil can be stockpiled and used to reclaim areas disturbed during construction. The main limitations for roads are low soil strength and high shrink-swell potential. The load bearing capacity of the soil can be improved by spreading gravel fill before constructing buildings or roads. Cutbanks are not stable and are subject to slumping.

Slope is a concern in installing septic tank absorption fields. Absorption lines should be installed on the contour. If this unit is used for septic tank absorption fields, the limitation of slow permeability can be overcome by increasing the size of the absorption field. If the density of housing is moderate to high, community sewage systems are needed to prevent contamination of local streams as a result of seepage from onsite sewage disposal systems.

The main limitations of this unit for recreational development are the hazard of erosion and the clayey texture of the soil. Plant cover can be maintained by limiting traffic. Drainage should be provided for paths and trails. Cuts and fills should be seeded or mulched.

This map unit is in capability subclass IIIe.

47—Shioya loamy sand, 0 to 5 percent slopes. This deep and very deep, excessively drained soil is on coastal strands. It formed in water-deposited coral sand. Areas typically are long and narrow and are parallel to the shoreline. The vegetation is mainly forest. Elevation is 0 to 10 meters.

Typically, the surface layer is dark brown loamy sand about 25 centimeters thick. The substratum to a depth of more than 150 centimeters is very pale brown sand. The soil is mildly alkaline to moderately alkaline. A buried surface layer is common in some areas. The surface layer has been removed in some recreational and residential areas.

Included in this unit are small areas of Inarajan sandy clay loam adjacent to coastal plains and valleys, Pulantat soils adjacent to uplands, and Rock outcrop along the shoreline. Also included are small areas of soils that are underlain with very gravelly and cobbly sand or are shallow to porous coral bedrock. Included areas make up about 15 percent of the total hectarage.

Permeability of this Shioya soil is rapid. Available water capacity is low. Effective rooting depth is more than 150 centimeters. Runoff is slow, and the hazard of water erosion is slight.

This unit is used mainly for recreation, wildlife habitat, and homesite development. It is also used for

subsistence and commercial farming. It can be used for grazing.

The main limitation of this unit for recreational development is the risk of damage from waves during typhoons. Facilities should be as far from the ocean as feasible, and they should be designed to withstand high waves and wind. Plant cover can be maintained by limiting traffic.

The use of this unit as wildlife habitat can be enhanced by maintaining the forest cover.

This unit is poorly suited to homesite development. The main limitation is the risk of damage from waves during typhoons. Buildings should be constructed as far from the ocean as feasible. Cutbanks are not stable and are subject to slumping.

Septic tank absorption fields on this unit do not filter effluent properly. If the density of housing is moderate to high, community sewage systems are needed to prevent contamination of water supplies as a result of seepage from onsite sewage disposal systems.

This unit is poorly suited to subsistence farming. The main limitations are the low available water capacity, high content of salt, and low soil fertility. Crops can be damaged by saline spray and wind. Crops should be planted as far from the open coastline as possible. Windbreaks are needed on the oceanside. Irrigation is necessary for fruit and vegetables planted on this unit. The unit is poorly suited to salt-sensitive crops. Compost can be applied to improve soil fertility.

This unit is poorly suited to commercial production of fruits and vegetables. It is poorly suited to salt-sensitive crops. The main limitations are droughtiness, high content of salt, and low soil fertility. Crops can be damaged by saline spray and wind. Crops should be planted as far from the open coastline as possible. Windbreaks are needed on the oceanside. Irrigation is required for maximum production of crops. Drip irrigation is suited to this unit. Water should be applied in amounts sufficient to wet the root zone but in amounts small enough to minimize the leaching of plant nutrients. Crops respond to fertilizer. The organic matter content can be maintained by rotating crops and by plowing under cover crops and all crop residue.

This unit is moderately suited to grazing. The main limitation is the low available water capacity. The quality of tropical forage is extremely low if it is allowed to mature. Livestock rotation improves the quality of forage and helps to prevent erosion caused by overstocking and trailing. The quality of forage can be improved by introducing adapted grasses and legumes. Yield can be increased by fertilizing. Practices such as salting, constructing livestock watering facilities, fencing, mowing or dragging, and protecting the unit from fire can be used to enhance the carrying capacity of the soil.

This map unit is in capability subclass IVs.

48—Togcha-Akina silty clays, 3 to 7 percent slopes. This map unit is on volcanic uplands. Slopes are broad and undulating. The vegetation in areas not cultivated is mainly grasses and forbs. Elevation is 30 to 300 meters.

This unit is 65 percent Togcha silty clay and 25 percent Akina silty clay. The Togcha soil is in concave areas and on lower slopes. The Akina soil is in convex areas and on upper slopes. The components of this unit are so intricately intermingled that it was not practical to map them separately.

The Togcha soil is very deep and well drained. It formed in alluvium derived dominantly from tuff and tuff breccia. Typically, the surface layer is dark reddish brown silty clay about 13 centimeters thick. The subsoil is dark red and yellowish red silty clay about 58 centimeters thick. The substratum is stratified red and dark red silty clay to a depth of more than 150 centimeters. The soil is strongly acid to medium acid.

Permeability of this Togcha soil is moderate. Available water capacity is moderate. Effective rooting depth is 150 centimeters or more. Runoff is medium, and the hazard of water erosion is moderate. Some lower lying areas are saturated with water for brief periods during the rainy season.

The Akina soil is moderately deep and well drained. It formed in residuum derived dominantly from tuff and tuff breccia. Typically, the surface layer is dark reddish brown silty clay about 10 centimeters thick. The subsoil is dark red clay about 51 centimeters thick. Dark red and white saprolite that crushes to silty clay is at a depth of 61 centimeters. Depth to saprolite ranges from 51 to 102 centimeters. In some areas the upper part of the soil formed in alluvium. The soil is very strongly acid to strongly acid throughout.

Permeability of this Akina soil is moderately slow. Available water capacity is moderate. Effective rooting depth is 51 to 102 centimeters. Runoff is medium, and the hazard of water erosion is moderate.

Included in this unit are small areas of Atate soils on upper slopes and Ylig soils in depressional areas. Also included are small areas of soils that have short, moderately steep slopes, soils that are nearly level, Badland, and eroded soils that are intermingled with areas of the Akina soil. Included areas make up about 10 percent of the total hectarage.

This unit is used mainly for subsistence and commercial farming and as watershed and wildlife habitat. It is also used for grazing. It can be used for homesite and recreational development.

This unit is well suited to subsistence production of vegetables and moderately suited to subsistence production of fruit trees. The main limitations are low soil fertility, soil acidity, and droughtiness during the dry season. Wherever feasible, areas of the Togcha soil should be used rather than areas of the Akina soil. Compost can be applied to improve soil fertility. Crushed

coral limestone can be mixed into the soil to provide calcium and to reduce soil acidity. During the dry season, irrigation is needed for shallow-rooted vegetables. Growth and production of banana, papaya, and other fruit trees can be increased by irrigating during the dry season.

This unit is well suited to commercial production of vegetables and moderately suited to commercial production of fruit trees. Crops that can be grown are those adapted to clayey, acidic soils, such as watermelons, Chinese and head cabbages, and fruit trees. The main limitations are the hazard of erosion, low soil fertility, soil acidity, and droughtiness during the dry season. In field designs, maximize the use of areas of the Togcha soil and minimize use of areas of the Akina soil. All tillage should be across the slope. Erosion can be reduced by avoiding clean cultivation, by installing grassed waterways, diversions, or terraces, and by mulching or planting cover crops. Crops respond to fertilizer and lime. The organic matter content can be maintained by rotating crops and by plowing under cover crops and all crop residue. During the dry season, irrigation is required for maximum production of crops. Drip irrigation is suited to this unit. Windbreaks are needed for the production of crops.

The use of this unit as wildlife habitat and watershed can be enhanced by protecting the unit from wildfires and by planting adapted trees. Establishing firebreaks and restricting public access can help to prevent wildfires. Prescribed burning of adjacent cropland should be closely supervised. Forest cover improves the watershed by reducing surface runoff and erosion. It also provides valuable cover for wildlife.

This unit is well suited to grazing. The quality of tropical forage is extremely low if it is allowed to mature. Livestock rotation improves the quality of forage and helps to prevent erosion caused by overstocking and trailing. The quality of forage can be improved by introducing adapted grasses and legumes. Yield can be increased by fertilizing and liming. Practices such as salting, constructing livestock watering facilities, fencing, mowing or dragging, and protecting the unit from fire can be used to enhance the carrying capacity of the soil and to prevent erosion.

This unit is moderately suited to homesite development. The main limitations are low soil strength, the hazard of erosion, and the moderate shrink-swell potential of the Togcha soil. The main limitation for roads is low soil strength. The load bearing capacity of the soil can be improved by spreading gravel fill before constructing buildings or roads. The effects of shrinking and swelling can be minimized by using proper engineering designs and by removing the soil and backfilling with suitable material. Preserving the existing plant cover during construction and revegetating disturbed areas around construction sites as soon as possible help to control soil erosion. Topsoil can be stockpiled and used to reclaim areas disturbed during construction.

Septic tank absorption fields should be installed in areas of the Togcha soil if feasible. If the Akina soil is used for septic tank absorption fields, the limitation of moderately slow permeability can be overcome by increasing the size of the absorption field. If the density of housing is moderate to high, community sewage systems are needed to prevent contamination of local streams as a result of seepage from onsite sewage disposal systems.

If this unit is used for recreational development, the main limitations are the clayey texture of the soils and the hazard of erosion. Plant cover can be maintained by limiting traffic.

This map unit is in capability subclass IIe.

49—Togcha-Akina silty clays, 7 to 15 percent slopes. This map unit is on volcanic uplands. Slopes are broad and gently rolling. The vegetation is mainly grasses. Elevation is 30 to 300 meters.

This unit is 65 percent Togcha silty clay and 25 percent Akina silty clay. The Togcha soil is in concave areas and on lower slopes. The Akina soil is in convex areas and on upper slopes. The components of this unit are so intricately intermingled that it was not practical to map them separately.

The Togcha soil is very deep and well drained. It formed in alluvium derived dominantly from tuff and tuff breccia. Typically, the surface layer is dark reddish brown silty clay about 13 centimeters thick. The subsoil is dark red and yellowish red silty clay about 58 centimeters thick. The substratum is red and dark red silty clay to a depth of more than 150 centimeters. The soil is strongly acid to medium acid.

Permeability of this Togcha soil is moderate. Available water capacity is moderate. Effective rooting depth is 150 centimeters or more. Runoff is medium, and the hazard of water erosion is moderate. Some lower lying areas are saturated with water for brief periods during the rainy season.

The Akina soil is moderately deep and well drained. It formed in residuum derived dominantly from tuff and tuff breccia. Typically, the surface layer is dark reddish brown silty clay about 10 centimeters thick. The subsoil is dark red clay about 51 centimeters thick. Dark red and white saprolite that crushes to silty clay is at a depth of 61 centimeters. Depth to saprolite is 51 to 102 centimeters. In some areas the upper part of the soil formed in alluvium. The soil is very strongly acid to strongly acid throughout.

Permeability of this Akina soil is moderately slow. Available water capacity is moderate. Effective rooting depth is 51 to 102 centimeters. Runoff is medium, and the hazard of water erosion is moderate.

Included in this unit are small areas of Atate soils on upper slopes, Ylig soils in depressional areas, and

Badland. Also included are small areas of nearly level soils on ridgelines and benches and small areas of soils that have short, steep slopes. Included areas make up about 10 percent of the total hectarage.

This unit is used mainly as wildlife habitat and watershed. It is also used for subsistence and commercial farming. It can be used for grazing, homesites, and recreational development.

The use of this unit as wildlife habitat and watershed can be enhanced by protecting the unit from wildfires and by planting adapted trees. Establishing firebreaks and restricting public access can help to prevent wildfires. Prescribed burning of adjacent cropland should be closely supervised. Forest cover improves the watershed by reducing surface runoff and erosion. It also provides valuable cover for wildlife.

This unit is well suited to subsistence production of vegetables and moderately suited to subsistence production of fruit trees. The main limitations are low soil fertility, soil acidity, the hazard of erosion, and droughtiness during the dry season. Wherever feasible, areas of the Togcha soil should be used rather than areas of the Akina soil. Compost can be applied to improve soil fertility. Crushed coral limestone can be mixed into the soil to provide calcium and to reduce soil acidity. Clean cultivation should be avoided. Weeds can be controlled by mulching and mowing. During the dry season, irrigation is needed for shallow-rooted vegetables. Growth and production of banana, papaya, and other fruit trees can be increased by irrigating during the dry season.

This unit is well suited to commercial production of vegetables and moderately suited to commercial production of fruit trees. Crops that can be grown are those adapted to clayey, acidic soils, such as watermelons, head and Chinese cabbages, and fruit trees. The main limitations are the hazard of erosion, low soil fertility, soil acidity, and droughtiness during the dry season. In field designs, maximize use of areas of the Togcha soil and minimize use of areas of the Akina soil. All tillage should be across the slope. Erosion can be reduced by avoiding clean cultivation, by installing grassed waterways, diversions, or terraces, and by planting cover crops. Crops respond to fertilizer and lime. The organic matter content can be maintained by rotating crops and by plowing under cover crops and all crop residue. During the dry season, irrigation is required for maximum production of crops. Drip irrigation is suited to this unit. Windbreaks are needed for the production of crops.

This unit is well suited to grazing. The quality of tropical forage is extremely low if it is allowed to mature. Livestock rotation improves the quality of forage and helps to prevent erosion caused by overstocking and trailing. The quality of forage can also be improved by introducing adapted grasses and legumes. Yield can be increased by fertilizing and liming. Practices such as salting, constructing livestock watering facilities, fencing, mowing or dragging, and protecting the unit from fire can be used to enhance the carrying capacity of the soil and to prevent erosion.

This unit is moderately suited to homesite development. The main limitations are slope and the moderate shrink-swell potential of the Togcha soil. Preserving the existing plant cover during construction and revegetating disturbed areas around construction sites as soon as possible help to control erosion. Topsoil can be stockpiled and used to reclaim areas disturbed during construction. The main limitation for roads is low soil strength. The load bearing capacity of the soil can be improved by spreading gravel fill before constructing buildings or roads. The effects of shrinking and swelling can be minimized by using proper engineering designs and by removing the soil and backfilling with suitable material.

If this unit is used for septic tank absorption fields, slope is a concern. Absorption lines should be installed on the contour. If the Akina soil is used for septic tank absorption fields, the limitation of moderately slow permeability can be overcome by increasing the size of the absorption field. If the density of housing is moderate to high, community sewage systems are needed to prevent contamination of local streams as a result of seepage from onsite sewage disposal systems.

The main limitations of this unit for recreational development are the hazard of erosion, slope, and the clayey texture of the soils. Plant cover can be maintained by limiting traffic. Playgrounds, ball fields, and other recreation areas that require level slopes are difficult to establish on the unit.

This map unit is in capability subclass IIIe.

50—Togcha-Ylig complex, 3 to 7 percent slopes. This map unit is on lower slopes and in valleys on volcanic uplands. Slopes are concave and commonly are incised by stream channels. Areas are mainly long and narrow. The vegetation on the Togcha soil is mainly grasses, and the vegetation on the Ylig soil is wetland forest, grasses, and sedges. Elevation is 30 to 300 meters.

This unit is 60 percent Togcha silty clay, and 35 percent Ylig clay. The Togcha soil is on lower side slopes. The Ylig soil is on valley bottoms and in depressional areas and commonly is in nearly level areas. In many areas the surface is hummocky. The components of this unit are so intricately intermingled that it was not practical to map them separately.

The Togcha soil is very deep and well drained. It formed in alluvium derived dominantly from tuff and tuff breccia. Typically, the surface layer is dark reddish brown silty clay about 13 centimeters thick. The subsoil is dark red and yellowish red silty clay about 58 centimeters thick. The substratum to a depth of more

than 150 centimeters is red and dark red silty clay. The soil is strongly acid to medium acid.

Permeability of this Togcha soil is moderate. Available water capacity is moderate. Effective rooting depth is more than 150 centimeters. Runoff is medium, and the hazard of water erosion is moderate. Some lower lying areas are saturated with water for brief periods during the rainy season.

The Ylig soil is very deep and somewhat poorly drained. It formed in alluvium derived dominantly from volcanic rock. Typically, the surface layer is dark brown clay about 13 centimeters thick. The underlying material to a depth of more than 150 centimeters is stratified, mottled clay and clay loam that ranges from gray, grayish brown, and dark brown to yellowish red and red. The soil is slightly acid to very strongly acid.

Permeability of this Ylig soil is moderately slow. Available water capacity is very high. Effective rooting depth is more than 150 centimeters. Runoff is medium, and the hazard of water erosion is moderate. A seasonal high water table fluctuates between depths of 25 and 102 centimeters during the rainy season, and it recedes during the dry season. This soil is subject to brief periods of flooding during the rainy season. The surface may crack during the dry season.

Included in this unit are small areas of Akina soils along the upper slopes, poorly drained soils in seep areas and depressional areas, and Agfayan soils in areas where streams have incised the soils to bedrock. Also included are small areas of level soils and steeper soils. Included areas make up about 5 percent of the total hectarage.

This unit is used mainly as watershed and wildlife habitat. It is also used for subsistence and commercial farming (fig. 10). It can be used for grazing, homesites, and recreational development.

The use of this unit as wildlife habitat and watershed can be enhanced by maintaining plant cover in areas of the Ylig soil and by planting adapted trees in areas of the Togcha soil. The unit should be protected from wildfires. Establishing firebreaks and restricting public access can help to prevent wildfires. Prescribed burning of adjacent cropland should be closely supervised. Forest cover improves the watershed by reducing surface runoff and erosion. It also provides valuable

Figure 10.—Area of Togcha-Ylig complex, 3 to 7 percent slopes, that is used for farming.

cover for wildlife. Open water areas along streams provide important habitat for wildlife. Practices that increase the size or duration of open water areas while preserving the surrounding vegetation improve the habitat.

The Togcha soil is moderately suited to subsistence farming. The Ylig soil is moderately suited to crops that tolerate wetness and to vegetables grown in the dry season. The Ylig soil is poorly suited to banana, citrus, and other fruit trees that do not tolerate seasonal wetness. Fruit trees can be planted in areas where drainage is better, such as along incised streambanks. The main limitations of the Togcha soil are low soil fertility, soil acidity, and droughtiness during the dry season. The main limitations of the Ylig soil are wetness and the hazard of flooding during the rainy season. Where feasible, areas of the Togcha soil should be used rather than areas of the Ylig soil. Compost can be applied to improve soil fertility. Crushed coral limestone can be mixed into the soil to provide calcium and to reduce soil acidity. During the dry season, irrigation is needed for shallow-rooted vegetables. Growth and production of banana, papaya, and other fruit trees can be increased by irrigating during the dry season.

The Togcha soil is moderately suited to commercial farming. Crops that can be grown are those adapted to clayey, acidic soil, such as watermelons and Chinese and head cabbages. This unit is poorly suited to production of fruit and to production of vegetables during the rainy season. The main limitations are the seasonal high water table and the hazard of flooding on the Ylig soil, the hazard of erosion, soil acidity, low soil fertility, and droughtiness during the dry season. Surface ditches or a subsurface drainage system can be used to lower the water table and remove excess water from the Ylig soil. A suitable outlet is needed. All tillage should be across the slope. Use of diversions, terraces, hillside ditches, and grassed waterways helps to control erosion. Crops respond to fertilizer and lime. The organic matter content can be maintained by using all crop residue, plowing under cover crops, and using a suitable rotation. During the dry season, irrigation is needed. Drip irrigation is suited to this unit. Windbreaks are needed for the production of crops.

This unit is moderately suited to grazing. The main limitation is wetness during the rainy season. Restricting grazing during wet periods helps to keep the pasture in good condition. Grazing when the soil is wet results in compaction of the surface layer and excessive runoff. The quality of tropical forage is extremely low if it is allowed to mature. Livestock rotation improves the quality of forage and helps to prevent erosion caused by overstocking and trailing. The quality of forage can also be improved by introducing adapted grasses and legumes. Yield can be increased by fertilizing and liming. Practices such as salting, constructing livestock watering facilities, fencing, mowing or dragging, and protecting the unit from fire can be used to enhance the carrying capacity of the soil and to prevent erosion.

The Togcha soil is moderately suited to homesite development. The main limitation is moderate shrink-swell potential. The main limitation for roads is low soil strength. The load bearing capacity of the soil can be improved by spreading gravel fill before constructing buildings or roads. The effects of shrinking and swelling can be minimized by using proper engineering designs and by removing the soil and backfilling with suitable material. Preserving the existing plant cover during construction and revegetating disturbed areas around construction sites as soon as possible help to control soil erosion. Topsoil can be stockpiled and used to reclaim areas disturbed during construction. If the density of housing is moderate to high, community sewage systems are needed to prevent contamination of local streams as a result of seepage from onsite sewage disposal systems.

The Ylig soil is poorly suited to homesite development. The main limitations are the seasonal high water table, the hazard of flooding, and high shrink-swell potential. Drainage is needed if roads and building foundations are constructed. Use of foundation drains and proper grading helps to overcome wetness problems for new homes. Dikes and channels that have outlets for floodwater can be used to protect buildings and onsite sewage disposal systems from flooding during the rainy season. The main limitation for roads is low soil strength. Roads and streets should be located above the expected flood level. The load bearing capacity of the soil can be improved by spreading gravel fill before constructing buildings or roads. The effects of shrinking and swelling can be minimized by using proper engineering designs and by removing the soil and backfilling with suitable material. Septic tank absorption fields do not function properly because of the seasonal high water table.

If this unit is used for recreational development, the main limitations are the seasonal wetness and low strength of the Ylig soil and the hazard of erosion of the Togcha soil. Plant cover can be maintained by limiting traffic. Drainage should be provided for paths and trails.

The Togcha soil is in capability subclass IIe. The Ylig soil is in capability subclass IIIw.

51—Togcha-Ylig complex, 7 to 15 percent slopes. This map unit is on lower slopes and in valleys on volcanic uplands. Slopes are concave and commonly are incised by stream channels. Areas are mainly long and narrow. The vegetation on the Togcha soil is mainly grasses, and the vegetation on the Ylig soil is wetland forest, grasses, and sedges. Elevation is 30 to 300 meters.

This unit is 60 percent Togcha silty clay and 35 percent Ylig clay. The Togcha soil is on lower side slopes. The Ylig soil is in seep areas, on valley bottoms, and in depressional areas. In many areas the surface is

hummocky. The components of this unit are so intricately intermingled that it was not practical to map them separately.

The Togcha soil is very deep and well drained. It formed in alluvium derived dominantly from tuff and tuff breccia. Typically, the surface layer is dark reddish brown silty clay about 13 centimeters thick. The subsoil is dark red and yellowish red silty clay about 58 centimeters thick. The substratum is red and dark red silty clay to a depth of more than 150 centimeters. The soil is strongly acid to medium acid.

Permeability of this Togcha soil is moderate. Available water capacity is moderate. Effective rooting depth is more than 150 centimeters. Runoff is medium, and the hazard of water erosion is moderate. Some lower lying areas are saturated with water for brief periods during the rainy season.

The Ylig soil is very deep and somewhat poorly drained. It formed in alluvium derived dominantly from volcanic rock. Typically, the surface layer is dark brown clay about 13 centimeters thick. The underlying material to a depth of more than 150 centimeters is stratified, mottled clay and clay loam that ranges from gray, grayish brown, and dark brown to yellowish red and red. The soil is slightly acid to very strongly acid.

Permeability of this Ylig soil is moderately slow. Available water capacity is very high. Effective rooting depth is more than 150 centimeters. Runoff is medium, and the hazard of water erosion is moderate. A seasonal high water table fluctuates between depths of 25 and 102 centimeters during the rainy season, and it recedes during the dry season. This soil is subject to brief periods of flooding during the rainy season. The surface may crack during the dry season.

Included in this unit are small areas of Akina soils along the upper slopes, poorly drained soils in seep areas and depressional areas, and Agfayan soils in areas where streams have incised the soils to bedrock. Also included are small areas of nearly level soils and steeper soils. Included areas make up about 5 percent of the total hectarage.

This unit is used mainly as watershed and wildlife habitat. It is also used for subsistence and commercial farming. It can be used for grazing, homesites, and recreational development.

The use of this unit as wildlife habitat and watershed can be enhanced by maintaining the plant cover in areas of the Ylig soil and by planting adapted trees in areas of the Togcha soil. The unit should be protected from wildfires. Establishing firebreaks and restricting public access can help to prevent wildfires. Prescribed burning on adjacent cropland should be closely supervised. Forest cover improves the watershed by reducing surface runoff and erosion. It also provides valuable cover for wildlife.

The Togcha soil is moderately suited to most subsistence farming. The main limitations are the hazard of erosion, low soil fertility, soil acidity, and droughtiness during the dry season. The Ylig soil is well suited to crops that tolerate wetness and to vegetables grown during the dry season. It is poorly suited to fruit trees that do not tolerate seasonal wetness or flooding during the rainy season. Fruit trees can be planted in areas where drainage is better, such as along incised streambanks. Wherever feasible, areas of the Togcha soil should be used rather than areas of the Ylig soil. Clean cultivation should be avoided. Weeds can be controlled by mulching and mowing. Compost can be applied to improve soil fertility. Crushed coral limestone can be mixed into the soil to provide calcium and to reduce soil acidity. During the dry season, irrigation is needed for shallow-rooted vegetables. Growth and production of banana, papaya, and other fruit trees can be increased by irrigating during the dry season.

This unit is moderately suited to commercial farming. Crops, such as watermelons and Chinese and head cabbages, that are adapted to clayey, acidic soils can be grown during the dry season. This unit is poorly suited to production of fruit and to production of vegetables during the rainy season. The main limitations are the seasonal high water table and hazard of flooding on the Ylig soil, the hazard of erosion, soil acidity, low soil fertility, and droughtiness during the dry season. Surface ditches or a subsurface drainage system can be used to lower the water table and remove excess surface water from the Ylig soil. A suitable outlet is needed. All tillage should be across the slope. An erosion control system, including use of diversions, terraces, hillside ditches, and grassed waterways, is needed. Crops respond to fertilizer and lime. The organic matter content can be maintained by rotating crops and by plowing under cover crops and all crop residue. During the dry season, irrigation is needed, Drip irrigation is suited to this unit. Windbreaks are needed for the production of crops.

This unit is moderately suited to grazing. The Togcha soil is limited mainly by the hazard of erosion. The Ylig soil is limited mainly by wetness during the rainy season. Grazing when the soil is wet results in compaction of the surface layer and excessive runoff. The quality of tropical forage is extremely low if it is allowed to mature. Livestock rotation improves the quality of forage and helps to prevent erosion caused by overstocking and trailing. The quality of forage can be improved by introducing adapted grasses and legumes. Yield can be increased by fertilizing and liming. Practices such as salting, constructing livestock watering facilities, fencing, mowing or dragging, and protecting the unit from fire can be used to enhance the carrying capacity of the soil and to prevent erosion.

This Togcha soil is moderately suited to homesite development. The main limitations are slope and high shrink-swell potential. Preserving the existing plant cover during construction and revegetating disturbed areas around construction sites as soon as possible help to

control erosion. Topsoil can be stockpiled and used to reclaim areas disturbed during construction. Cutbanks are not stable and are subject to slumping. The main limitation for roads is low soil strength. The load bearing capacity of the soil can be improved by spreading gravel fill before constructing buildings or roads. The effects of shrinking and swelling can be minimized by using proper engineering designs and by removing the soil and backfilling with suitable material.

If the Togcha soil is used for septic tank absorption fields, slope is a concern. Absorption lines should be installed on the contour. If the density of housing is moderate to high, community sewage systems are needed to prevent contamination of local streams as a result of seepage from onsite sewage disposal systems.

The Ylig soil is poorly suited to homesite development. The main limitations are the seasonal high water table, high shrink-swell potential, and slope. Drainage is needed if roads and building foundations are constructed. Use of foundation drains and proper grading help to overcome wetness problems for new homes. Dikes and channels that have outlets for floodwater can be used to protect buildings and onsite sewage disposal systems from brief periods of flooding. Roads and streets should be located above the expected flood level. The main limitation for roads is low soil strength. The load bearing capacity of the soil can be improved by spreading gravel fill before constructing buildings or roads. Cutbanks are not stable and are subject to slumping. Septic tank absorption fields do not function properly on the Ylig soil because of the seasonal high water table.

If this unit is used for recreational development, the main limitations are the seasonal wetness of the Ylig soil, the hazard of erosion, and the low strength of the Togcha soil. Plant cover can be maintained by limiting traffic. Drainage should be provided for paths and trails.

The Togcha soil is in capability subclass IIIe. The Ylig soil is in capability subclass IIIw.

52—Troposaprists, 0 to 1 percent slopes. These deep, very poorly drained soils are in Agana Swamp, in central Guam. They formed in decomposed organic material derived dominantly from reeds, sedges, rushes, and other wetland plants. The vegetation is mainly phragmites and reeds. Elevation is sea level to 15 meters.

No single profile of Troposaprists is typical, but one commonly observed in the survey area has a surface layer of dark reddish brown peaty muck about 30 centimeters thick. The underlying material to a depth of more than 150 centimeters is very dark grayish brown and dark brown muck. The soils are neutral to mildly alkaline. Strata of mucky silty clay are present in some areas.

Permeability of these Troposaprists is moderate. Available water capacity is very high. Runoff is ponded, and the hazard of water erosion is slight. These soils have a permanent high water table. During the rainy season, the soils are flooded for prolonged periods. The water level is 20 to 70 centimeters above the soil surface during these periods.

Included in this unit are small areas of Inarajan and Inarajan Variant soils. Also included are small areas of Ustorthents and areas that have been filled and used for roads. Included areas make up about 10 percent of the total hectarage.

This unit is suited only to use as wildlife habitat and watershed. The main limitations for all other uses are the very low soil strength and the permanent high water table.

The use of this unit as wildlife habitat and watershed can be enhanced by preserving the plant cover. This unit provides important habitat for Mariana gallinule and other wildlife species.

This map unit is in capability subclass VIIw.

53—Urban land-Ustorthents complex, nearly level. This map unit is on coastal fill in and around Agana and Apra Harbors. Most areas are covered by roads, buildings, and parking lots. Slope is 0 to 3 percent. Elevation is 0 to 15 meters.

This unit is 60 percent Urban land and 30 percent Ustorthents.

Urban land consists of areas covered by buildings, roads, and parking lots. Some of these areas have a base of crushed coral, and some rest directly on limestone. Areas of Urban land are impermeable to water. Runoff is very rapid.

Ustorthents consist of quarried fill material. It commonly is crushed coral gravel and cobbles and a few pockets of very gravelly clay and clay loam. Some areas around buildings have been covered with a thin layer of clay or clay loam and have been planted with lawns and other landscaping plants. Weeds and low shrubs cover some unused areas.

Permeability of these Ustorthents is moderately rapid. Available water capacity is very low. Runoff is slow, and the hazard of water erosion is slight.

Included in this unit are small areas of Shioya soils along the coast and Inarajan and Inarajan Variant soils near wetland areas. Also included are small areas of soils that have short, steep slopes. Included areas make up about 10 percent of the total hectarage.

This unit is used as homesites, as commercial and industrial sites, and for other urban uses.

This unit is well suited to homesite development. Fertilization and irrigation are needed for the establishment of lawns and landscaping plants. In most areas topsoil must be brought in for successful establishment of plants.

The Ustorthents are in capability subclass VIIIs.

54—Ylig clay, 0 to 3 percent slopes. This very deep, somewhat poorly drained soil is along stream channels and in depressional areas on volcanic uplands. It formed in alluvium derived dominantly from volcanic rock. Slopes are level but generally are incised by stream channels. In many areas the surface is hummocky. Areas are elongated and narrow in shape. The vegetation is mainly wetland forest, grasses, and sedges. Elevation is 10 to 300 meters.

Typically, the surface layer is dark brown clay about 13 centimeters thick. The underlying material to a depth of more than 150 centimeters is stratified, mottled clay, silty clay, and clay loam that range from gray, grayish brown, and dark brown to yellowish red and red. The soil is slightly acid to very strongly acid.

Included in this unit are small areas of Inarajan Variant soils, soils on steep channel banks, and Togcha soils along the upper side slopes on uplands. Also included are small areas of gently sloping soils and Agfayan soils in areas where the streambed has been incised to bedrock. Some moderately well drained soils are along natural levees and streambanks in areas where the streambed is deeply incised. Included areas make up about 10 percent of the total hectarage.

Permeability of this Ylig soil is moderately slow. Available water capacity is very high. Effective rooting depth is more than 150 centimeters. Runoff is medium, and the hazard of water erosion is slight. A seasonal high water table fluctuates between depths of 25 and 102 centimeters during the rainy season, and it recedes during the dry season. This soil is subject to brief periods of flooding during the rainy season. In some areas the surface cracks during the dry season.

This unit is used as watershed and wildlife habitat. It can be used for grazing, subsistence and commercial farming, and recreational development. It is not suited to homesite development. The main limitations are the hazard of flooding and the seasonal high water table.

The use of this unit as wildlife habitat and watershed can be enhanced by maintaining the existing wetland vegetation. Open water areas along streams provide important habitat for wildlife. Practices that increase the size or duration of open water areas while preserving the surrounding vegetation improve the habitat.

This unit is moderately suited to grazing. The main limitation is wetness during the rainy season. Grazing when the soil is wet results in compaction of the surface layer and excessive runoff. Restricting grazing during wet periods helps to keep the pasture in good condition. Livestock rotation improves the quality of forage. The quality of forage can also be improved by introducing adapted grasses and legumes. Yield can be increased by fertilizing and liming. Practices such as salting, constructing livestock watering facilities, fencing, mowing or dragging, and protecting the unit from fire can be used to enhance the carrying capacity of the soil.

This unit is moderately suited to subsistence farming. It is limited mainly by seasonal wetness, the hazard of flooding, and droughtiness late in the dry season. Crops that tolerate wetness, such as taro, can be grown. Most vegetables can be grown only during the dry season. This unit is poorly suited to fruit trees that do not tolerate seasonal wetness. Fruit trees can be grown along natural levees and in areas of the better drained included soils. Mechanical tillage and vehicle traffic should be avoided when the soil is wet. During the dry season, irrigation is needed for shallow-rooted vegetables and fruit trees. Compost can be applied to improve soil fertility. Crushed coral limestone can be mixed into the soil to provide calcium and to reduce soil acidity.

This unit is poorly suited to commercial farming. Crops that can be grown during the dry season include beans, watermelons, and Chinese and head cabbages. The main limitations are the included area of poorly drained soils, soil acidity, and droughtiness late in the dry season. Most areas of this unit are poorly suited to banana and other fruit trees that are sensitive to wetness. In most areas, artificial drainage is necessary for commercial production of fruit. Farming this unit is not feasible during the rainy season. The narrowness of areas of the unit and the presence of streams that commonly are deeply incised and meandering restrict field size and design. During the dry season, irrigation is required for maximum production of row crops. Drip irrigation is suited to this unit. The organic matter content can be maintained by using all crop residue, plowing under the cover crops, and using a suitable rotation. Crops respond to fertilizer and lime. Field operations should be avoided after heavy rains. Ditches or a subsurface drainage system can be used to remove excess water.

The main limitation of this unit for recreational development is seasonal wetness. Plant cover can be maintained by limiting traffic. Drainage should be provided for paths and trails.

This map unit is in capability subclass IIIw.

55—Ylig clay, 3 to 7 percent slopes. This very deep, somewhat poorly drained soil is along stream channels and in depressional areas and seep areas on volcanic uplands. It formed in alluvium derived dominantly from volcanic rock. Slopes are long and concave and commonly are incised by stream channels. In many areas the surface is hummocky. Areas are elongated and narrow in shape. The vegetation is mainly wetland forest, grasses, and sedges. Elevation is 10 to 300 meters.

Typically, the surface layer is dark brown clay about 13 centimeters thick. The underlying material to a depth of more than 150 centimeters is stratified, mottled clay, silty clay, and clay loam that range from gray, grayish brown,

and dark brown to yellowish red and red. The soil is slightly acid to very strongly acid.

Included in this unit are small areas of Inarajan Variant soils, soils on steep channel banks, moderately sloping Ylig soils in seep areas and upper valleys, and Togcha soils along the upper side slopes of uplands. Also included are nearly level soils and Agfayan soils in areas where the streambed is incised to bedrock. Some moderately well drained soils are along streambanks in areas where the stream is deeply incised. Included areas make up about 10 percent of the total hectarage.

Permeability of this Ylig soil is moderately slow. Available water capacity is very high. Effective rooting depth is more than 150 centimeters. Runoff is medium, and the hazard of water erosion is moderate. A seasonal high water table fluctuates between depths of 25 and 102 centimeters during the rainy season, and it recedes during the dry season. This soil is subject to brief periods of flooding during the rainy season. The surface may crack during the dry season.

This unit is used as watershed and wildlife habitat. It can be used for grazing, subsistence and commercial farming, and recreational development. The unit is not suited to homesite development. The main limitations are the seasonal high water table and the brief periods of flooding during the rainy season.

The use of this unit as wildlife habitat and watershed can be enhanced by maintaining the existing wetland vegetation. Open water areas along streams provide important habitat for wildlife. Practices that increase the size or duration of open water areas while preserving the surrounding vegetation improve the habitat.

This unit is moderately suited to grazing. The main limitation is wetness during the rainy season. Grazing when the soil is wet results in compaction of the surface layer and excessive runoff. Livestock rotation improves the quality of forage and helps to prevent erosion caused by overstocking and trailing. The quality of forage also can be improved by introducing adapted grasses and legumes. Yield can be increased by fertilizing and liming. Practices such as salting, constructing livestock watering facilities, fencing, mowing or dragging, and protecting the unit from fire can be used to enhance the carrying capacity of the soil and to prevent erosion.

This unit is moderately suited to subsistence farming. Crops that tolerate wetness, such as taro, can be grown. Most vegetables can be grown only during the dry season. The main limitations are seasonal soil wetness, the hazard of flooding, the included areas of poorly drained soils, the susceptibility of the soil to compaction, and droughtiness late in the dry season. This unit is poorly suited to banana, citrus, and other fruit trees that do not tolerate seasonal wetness. Fruit trees can be grown along natural levees and in areas of better drained included soils. Mechanical tillage and vehicle traffic should be avoided when the soil is wet. During the dry season, irrigation is needed for shallow-rooted vegetables and fruit trees. Compost can be applied to improve soil fertility. Crushed coral limestone can be mixed into the soil to provide calcium and to reduce soil acidity.

This unit is poorly suited to commercial farming. Crops that can be grown during the dry season and are adapted to clayey, acidic soils include beans, watermelons, and head and Chinese cabbages. The main limitations are seasonal wetness, the hazard of flooding, the included areas of poorly drained soils, the susceptibility of the soil to compaction, soil acidity, and droughtiness late in the dry season. Most areas of this unit are poorly suited to fruit trees that are sensitive to wetness. In most areas artificial drainage is necessary for commercial production of fruit. Farming this unit is not feasible during the rainy season. The narrow areas and the presence of streams that commonly are deeply incised and meandering restrict field size and design. Field operations should be avoided after heavy rains. Ditches or a subsurface drainage system can be used to remove excess water. During the dry season, irrigation is required for maximum production of row crops. Drip irrigation is suited to this unit. The organic matter content can be maintained by using all crop residue, by plowing under cover crops, and by using a suitable rotation. Crops respond to fertilizer and lime. All tillage should be across the slope. Erosion can be reduced by avoiding clean cultivation, by installing diversions, terraces, or grassed waterways, and by planting cover crops.

The main limitation of this unit for recreational development is seasonal wetness. Plant cover can be maintained by limiting traffic. Drainage should be provided for paths and trails.

This map unit is in capability subclass IIIw.

Prime Farmland

In this section, prime farmland is defined and discussed and the prime farmland soils in this survey area are listed.

Prime farmland is of major importance in providing the nation's short- and long-range needs for food and fiber. The acreage of high-quality farmland is limited, and the U.S. Department of Agriculture recognizes that government at local, state, and federal levels, as well as individuals, must encourage and facilitate the wise use of our nation's prime farmland.

Prime farmland soils, as defined by the U.S. Department of Agriculture, are soils that are best suited to producing food, seed, forage, fiber, and oilseed crops. Such soils have properties that are favorable for the economic production of sustained high yields of crops. The soils need only to be treated and managed using acceptable farming methods. Adequate moisture and a sufficiently long growing season are required. Prime farmland soils produce the highest yields with minimal inputs of energy and economic resources, and farming these soils results in the least damage to the environment.

Prime farmland soils may presently be in use as cropland, pasture, or woodland, or they may be in other uses. They either are used for producing food and fiber or are available for these uses. Urban or built-up land, public land, and water areas cannot be considered prime farmland. Urban or built-up land is any contiguous unit of land 10 acres or more in size that is used for such purposes as housing, industrial, and commercial sites, sites for institutions or public buildings, small parks, golf courses, cemeteries, railroad yards, airports, sanitary landfills, sewage treatment plants, and water control structures. Public land is land not available for farming in national forests, national parks, military reservations, and state parks.

Prime farmland soils commonly get an adequate and dependable supply of moisture from precipitation or irrigation. Temperature and length of growing season are favorable, and level of acidity or alkalinity is acceptable. The soils have few, if any, rocks and are permeable to water and air. They are not excessively erodible or saturated with water for long periods and are not flooded during the growing season. The slope ranges mainly from 0 to 6 percent.

Soils that have a high water table, are subject to flooding, or are droughty may qualify as prime farmland soils if the limitations are overcome by drainage, flood control, or irrigation. Onsite evaluation is necessary to determine the effectiveness of corrective measures. More information on the criteria for prime farmland soils can be obtained at the local office of the Soil Conservation Service.

A recent trend in land use has been the conversion of prime farmland to urban and industrial uses. The loss of prime farmland to other uses puts pressure on lands that are less productive than prime farmland.

None of the map units in this survey qualify as prime farmland in their entirety; however, some of the major components in the following map units meet the soil requirements for prime farmland when irrigated. These components are given in parentheses following the map unit name.

27 Guam-Saipan complex, 0 to 7 percent slopes (Saipan soil)
39 Pulantat-Kagman clays, 0 to 7 percent slopes (Kagman soil)
48 Togcha-Akina silty clays, 3 to 7 percent slopes (Togcha soil)
50 Togcha-Ylig complex, 3 to 7 percent slopes (Togcha soil)

Use and Management of the Soils

This soil survey is an inventory and evaluation of the soils in the survey area. It can be used to adjust land uses to the limitations and potentials of natural resources and the environment. Also, it can help avoid soil-related failures in land uses.

In preparing a soil survey, soil scientists, conservationists, engineers, and others collect extensive field data about the nature and behavioral characteristics of the soils. They collect data on erosion, droughtiness, flooding, and other factors that affect various soil uses and management. Field experience and collected data on soil properties and performance are used as a basis in predicting soil behavior.

Information in this section can be used to plan the use and management of soils for crops and pasture; as rangeland and woodland; as sites for buildings, sanitary facilities, highways and other transportation systems, and parks and other recreation facilities; and for wildlife habitat. It can be used to identify the potentials and limitations of each soil for specific land uses and to help prevent construction failures caused by unfavorable soil properties.

Planners and others using soil survey information can evaluate the effect of specific land uses on productivity and on the environment in all or part of the survey area. The survey can help planners to maintain or create a land use pattern in harmony with the natural soil.

Contractors can use this survey to locate sources of sand and gravel, roadfill, and topsoil. They can use it to identify areas where bedrock, wetness, or very firm soil layers can cause difficulty in excavation.

Health officials, highway officials, engineers, and others may also find this survey useful. The survey can help them plan the safe disposal of wastes and locate sites for pavements, sidewalks, campgrounds, playgrounds, lawns, and trees and shrubs.

Crops

General management needed for crops and pasture is suggested in this section. The system of land capability classification used by the Soil Conservation Service is explained.

Planners of management systems for individual fields or farms should consider the detailed information given in the description of each soil under "Detailed Soil Map Units." Specific information can be obtained from the local office of the Soil Conservation Service or the Cooperative Extension Service.

Diverse agricultural systems are used in the survey area, ranging from traditional subsistence farming and gardening to modern commercial crop production. Perry (*13*) estimates that in 1978 there were more than 1,000 family gardens of about 0.1 hectare and about 400 subsistence farms of less than 2 hectares. Bjork (*7*) estimates that in 1983 there were 107 commercial farms on Guam with an average size of 2.7 hectares. The commercial farms range from 2 to 100 hectares. About 200 hectares were in production in 1983.

Virtually all of the commercial crops grown are vegetables and fruit. The most extensively grown crop is watermelons, which were planted on about 83 hectares in 1983. Other important commercial crops, listed in order of hectares planted, are cucumbers, long beans, tomatoes, cantaloups, and pepino melons. These crops were planted on about 62 hectares. Other important commercial crops are green beans, bittermelons, head cabbage, eggplants, bell peppers, sweet potatoes, and various varieties of squash.

Fruit crops generally are more important as subsistence crops than as cash crops, but bananas, coconuts, mangoes, citrus fruit (mainly lemons, oranges, and tangerines), avocados, and papayas are all marketed commercially. Commercial production of bananas and pineapples is increasing rapidly.

Field corn was once the most important crop in the survey area; it was grown extensively in central Guam. Commercial production of sweet corn is now increasing, but it requires careful management of pests. Rice was grown in all of the major valleys and coastal plains of southern Guam during the years of Japanese occupation; however, there is presently no commercial production of rice. Sugarcane can be grown in the area.

Subsistence farming and gardening continue to be important to the income and lifestyle of many families. The main subsistence crops include bananas, various varieties of green beans, bittermelons, breadfruit, citrus fruit, cassava (tapioca), coconuts, mangoes, papayas, peppers, sweet potatoes, taro, and yams.

The soils in the survey area are suitable for increased agricultural production; however, there are several restrictions. Land tenure and access are major limitations for increased production. Availability and reliability of irrigation water supplies is another important restraint.

Farmer education, dissemination of modern agricultural technology, and effective pest management are all needed. Marketing problems continue to trouble the agricultural community. Erratic local supply encourages the importation of many products that can be grown locally. Rainy season conditions and periodic storms and typhoons have a disruptive effect on consistent production. With 110,000 people on the island, the local market is quite limited. At present the only agricultural export is eggs, which are sent to Saipan.

Before World War II, agriculture was concentrated in the central part of the island, near Barrigada and Mangilao. Areas around the southern villages were also important. In central Guam, except for lands leased from the Navy, agriculture is restricted because of urbanization. Important agricultural areas in the south are now in and directly west of Talofofo Village, in Malojloj and the Dandan Basin, in Talofofo and Inarajan Valleys, and on the southern coastal plain. Agriculture in northern Guam is more spread out, but many farms are in the Ysengsong and Yigo areas.

There are distinct differences, both in kind of crops and management, between farming operations in the northern and southern parts of Guam. This is primarily a result of differences in the soils. The main soils in the northern part are Guam cobbly clay loam, which are very shallow and well drained. These soils are not well suited to farming; however, tomato, eggplant, and bell pepper are adapted to this area. Virtually all of the farming soils in the south are clay soils and are limited by wetness at some time during the year, either as a result of flooding or ponding or because the soils are saturated; this wetness prevents field operations for weeks at a time. The saturation also promotes bacterial wilt, a disease to which tomato, eggplant, and bell pepper plants are very susceptible. As a result, these important crops are not usually planted in southern Guam.

Watermelons, the single largest crop, are grown almost exclusively in southern Guam. Watermelon plants are tolerant of acidic soils such as those of the Akina, Togcha, and Ylig series. The moderate and very high water holding capacity of these soils, as well as that of the Inarajan, Chacha, Kagman, and Saipan soils, provides the large amounts of water necessary to fill out the fruit.

The volcanic soils, such as those of the Akina, Togcha, and Ylig series, are used for a very limited number of crops, primarily watermelons and pineapples. Both of these crops are adapted to acidic soils. With proper fertility management, including the use of lime, a much wider range of crops could be grown.

There have been some attempts at aquaculture on the Ylig soils, but all presently producing aquaculture units are on Inarajan soils (fig. 11). These soils are well suited to pond construction and are geographically well suited if brackish water is needed for the crop. Ylig soils are well suited to pond construction but are not close to brackish water.

Bananas and other fruit tree crops are poorly suited to northern Guam because of the restricted rooting depth and subsequent windthrow hazard. All of the deep, well drained soils of central and southern Guam are well suited to fruit trees if adequately fertilized. Inarajan and Ylig soils, which have a seasonal high water table, seem to vary from place to place in their suitability for fruit production. In particular, bananas grow very well in some areas but tend to die out quickly in other areas.

Vegetable production drops dramatically during the rainy season. This is the "typhoon season," which is characterized by a much higher incidence of damaging wind and rain than is the dry season. Previously mentioned flooding, ponding, and soil saturation occur in central and southern Guam. This is not a problem on the Guam cobbly clay loam in the north, but frequent rains interfere with fruit set, cause fruit to split, and create conditions that promote disease on crops grown during the rainy season. Wind damage can be particularly severe on the exposed northern plateau.

Irrigation is essential for commercial vegetable production on Guam. It is possible to plant a crop in a deep soil late in the rainy season, allowing the crop to mature without irrigation in the dry season. However, field access for planting is difficult and may result in serious soil compaction problems, and late season storms may damage the crop. Drip irrigation is the most commonly used method of irrigation. It is ideally suited to the Guam cobbly clay loam, because it allows for the light, frequent irrigation schedule necessary on this droughty soil. Drip irrigation works at low pressures (common during the dry season) and does not create erosion problems on the sloping soils. Some farms have inadequate irrigation systems; farmers irrigate with a tank truck and hose or with buckets.

Fertility management is another important aspect of commercial farming on Guam. Although topsoil in the soils of Guam is relatively high in organic matter content (4 to 8 percent is common), the surface layer is thin in most places. Any erosion dramatically reduces soil fertility. Organic matter is an important source of soil nutrients, and it increases nutrient-holding capacity. Saipan and Yigo soils in particular are virtually inert without organic matter; most plant nutrients will be leached out of the root zone with the irrigation or rain water. Organic matter decomposes quickly in Guam's warm temperatures, particularly in cultivated, irrigated soils. Thus, maintaining the organic matter content is an important aspect of fertility management on Guam. Careful land clearing, prevention of erosion, turning under crop residue, and growing cover crops are all management techniques that can be used to maintain organic matter content.

Inorganic commercial fertilizer is used in most commercial farming operations on Guam. Generally, a balanced fertilizer that includes nitrogen, phosphorus, and potassium should be used, although the exact

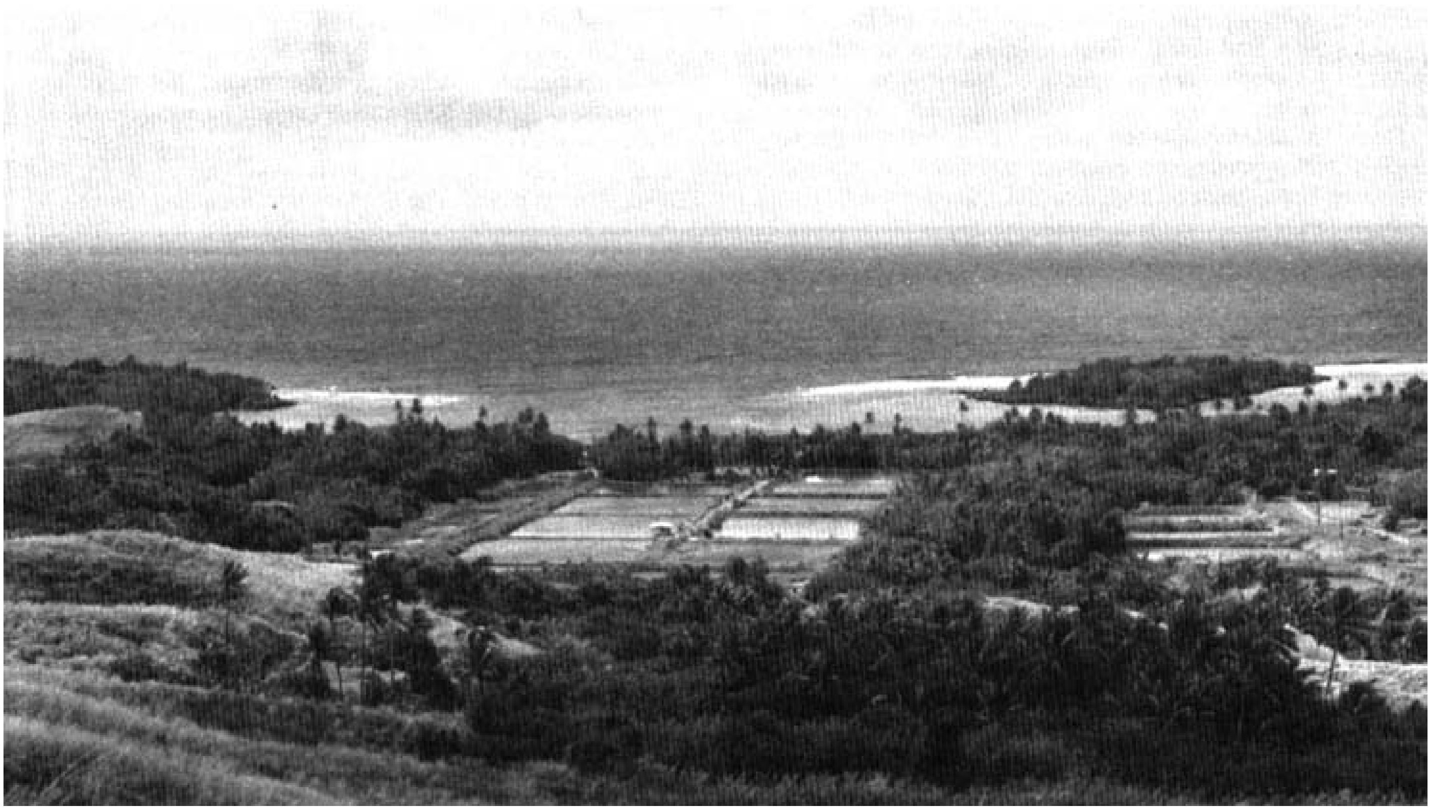


Figure 11.—Aquaculture in an area of Inarajan soils.

amount of each can be quite variable. The University of Guam provides a soil testing and fertilizer recommendation service for Guam's farmers. Contact the Agricultural Extension Service at the University of Guam for details.

Fertilizer management on Guam cobbly clay loam in the north is somewhat different than that on the deep soils in the south. Because nitrogen is quickly leached out of the soil, split applications of nitrogen are necessary, with one or more applications used as a sidedressing while the crop is growing. A fertilizer that includes ammonium as the nitrogen source is suitable because ammonium has an acidifying effect on this mildly alkaline soil. Because limestone is within the root zone, the soil is saturated with calcium carbonate and crops may show deficiencies of such micronutrients as zinc and iron. Foliar micronutrient sprays are often used by northern farmers to help correct this problem.

The acidic volcanic soils in the south, primarily the Akina, Togcha, and Ylig soils, present slightly different fertility problems. Although split applications of nitrogen are suitable, leaching of nitrogen is not so serious a problem as it is on Guam cobbly clay loam. Ammonium is not recommended as a nitrogen source because it tends to acidify the soil, and acidity is a symptom of two important fertility problems in this soil. Although not extensively studied on Guam, the problem of calcium deficiency and aluminum toxicity can be corrected by applying lime. This will allow a wider variety of crops to be grown on these soils, as well as a higher yield of presently grown crops.

All soils in Guam are initially low in phosphorus and will tend to fix about a quarter to a third of added phosphorus, releasing it slowly over time. For this reason, and because phosphorus does not move in the soil like nitrogen, phosphorus should be banded directly into the root zone.

Erosion generally is not a problem on Guam cobbly clay loam or Inarajan clay. Erosion can be a problem on the Kagman soils, particularly where excessive field traffic and cultivation have created a tillage pan in the dense clay below the surface layer. Water can accumulate and flow across the top of this layer, eroding away the surface even in gently sloping areas. Erosion is a serious concern in sloping areas of the Akina and Togcha soils. The Akina soils in particular have an infertile subsoil that should not be exposed. Accelerated badland erosion together with natural slumps can lead to heavy sedimentation of cropped fields and gullied

agricultural drainageways. Farming across the slope, stripcropping, and using terraces, diversions, and grassed waterways are all practices that can be used to reduce erosion.

Removal of excess water with ditches and subsurface drains could significantly lengthen the cropping season on some soils, such as those of the Inarajan and Chacha series.

Subsistence farming techniques and management practices are considerably different than those used for commercial farming; however, traditional subsistence farming is rare on Guam; most farmers make some cash investment in seed, bean fencing, and, perhaps, a rototiller.

Management of organic matter is very important in areas where commercial fertilizer is not used. Animal manure should be used whenever feasible. Weeds, crop residue, slash from surrounding vegetation, and manure can be mixed into a compost pile. Upon decomposition, the compost is used as fertilizer.

Mulching is also important on subsistence plots (*14*). Mulch helps to conserve moisture, reduces erosion in sloping areas, and prevents the soil surface from becoming excessively hot and dry. As the mulch decomposes, it adds nutrients to the soil. Slash from tangantangan (*Leucaena leucocephala*) is a good source of nitrogen if used in this manner; however, tangantangan inhibits germination of seeds (*15*) and should be used only around established plants. The needlelike leaves of ironwood (*Casuarina equisetifolia*) are reported to inhibit growth (*11*) and thus may not be suitable for use as mulch.

Subsistence plots can be established on soils that are too steep for commercial farming; however, clean cultivation should be avoided on sloping soils. Weeds around plants can be controlled by hand pulling and mulching. Undergrowth between plants or on plot borders can be controlled by mowing or slashing. Small terraces and embankments can be built by hand, using local material.

Many of Guam's best agricultural soils occur in a complex with more limiting soils. The deep soils that formed in sediment overlying limestone, such as those of the Kagman, Saipan, and Yigo series, are intermingled with the shallow Pulantat soils or the very shallow Guam soils. In detailed soil map unit 18, the Akina soil occurs with Badland. In units 50 and 51, the well drained Togcha soils occur with the somewhat poorly drained Ylig soils.

Commercial farm fields located on these soil complexes may have both soils within the field; thus, the field must be managed according to the most limiting soil component. As an example, consider the irrigation scheduling for a vegetable crop planted on the Guam-Yigo complex, 0 to 7 percent slopes. If irrigation events are scheduled for the deep Yigo soils, plants on the very shallow and droughty Guam soils will be stressed; thus, light, frequent irrigation events must be scheduled to meet the requirements of the limiting Guam soil. As another example, consider a commercial fruit orchard on the same unit. The Yigo soil is deep and well suited to fruit trees. The Guam soil, however, is very shallow and poorly suited. A large commercial orchard on this unit will have most trees on the Guam soil. Unless extreme measures are taken during planting, such as excavating the coral bedrock and backfilling with soil material from offsite, most of the orchard will grow and produce poorly.

Many commercial farm fields are relatively small, commonly smaller than the map unit delineation. In such cases, when a soil complex is to be farmed, the field commonly can be located in areas of the best soil in the complex. Management practices are then designed for the soil component that is being farmed.

To selectively farm individual components of a soil complex, the farmer must be able to distinguish between the two components. In the case of the Akina-Badland complex, 7 to 15 percent slopes, the Badland component is easily recognized and avoided. If a suitable large area of contiguous Akina soils is located, this area can be farmed using management techniques identical to those applicable on Akina silty clay, 7 to 15 percent slopes.

In detailed soil map units 27, 29, 37, 38, 39, and 40, in which the soils overlie limestone, the shallow soil component is in the higher lying, steeper areas whereas the deeper soil component is in lower lying, less sloping areas. If fields are located in the lowest areas of the units, use of the shallow soil component can be minimized; however, the exact boundary between the soil components is difficult to locate. In unit 29, simply plowing the area will reveal the extent of the very shallow Guam soil component because the tillage equipment will strike the coral bedrock.

The Chacha soils in units 37 and 38 are ponded in places for short periods and have a water table during much of the rainy season. Because of this, fruit crops are better suited to the shallow Pulantat soils. The deep Kagman soils of units 39 and 40 are well suited to fruit production, and orchard design should maximize the use of the Kagman soils in these complexes.

Field access is restricted by wetness during the rainy season on both the Kagman and Chacha soils. Ditches or a subsurface drainage system can be used to remove excess surface water from these soils. For shallow-rooted vegetables it may be more feasible to farm the Pulantat soil during the rainy season.

Units 50 and 51 are complexes of the well drained Togcha soils and the somewhat poorly drained Ylig soils. Field design on these units should maximize the use of the Togcha soils and minimize the use of the Ylig soils. The Ylig soils generally can be recognized as low-lying areas covered with kariso or sedges. A stream may also be present. The Togcha soils in units 50 and 51 can be managed like units 48 and 49, respectively.

Assistance for both subsistence and commercial farmers is available from the local office of the Soil Conservation Service and the Agricultural Extension Service.

Land Capability Classification

Land capability classification shows, in a general way, the suitability of soils for most kinds of field crops. Crops that require special management are excluded. The soils are grouped according to their limitations for field crops, the risk of damage if they are used for crops, and the way they respond to management. The grouping does not take into account major and generally expensive landforming that would change slope, depth, or other characteristics of the soils, nor does it consider possible but unlikely major reclamation projects. Capability classification is not a substitute for interpretations designed to show suitability and limitations of groups of soils for rangeland, for woodland, and for engineering purposes.

In the capability system, soils generally are grouped at three levels: capability class, subclass, and unit. Only class and subclass are used in this survey. These levels are defined in the following paragraphs.

Capability classes, the broadest groups, are designated by Roman numerals I through VIII. The numerals indicate progressively greater limitations and narrower choices for practical use. The classes are defined as follows:

Class I soils have few limitations that restrict their use.

Class II soils have moderate limitations that reduce the choice of plants or that require moderate conservation practices.

Class III soils have severe limitations that reduce the choice of plants or that require special conservation practices, or both.

Class IV soils have very severe limitations that reduce the choice of plants or that require very careful management, or both.

Class V soils are not likely to erode but have other limitations, impractical to remove, that limit their use.

Class VI soils have severe limitations that make them generally unsuitable for cultivation.

Class VII soils have very severe limitations that make them unsuitable for cultivation.

Class VIII soils and miscellaneous areas have limitations that nearly preclude their use for commercial crop production.

Capability subclasses are soil groups within one class. They are designated by adding a small letter, *e, w, s,* or *c,* to the class numeral, for example, IIe. The letter *e* shows that the main limitation is risk of erosion unless close-growing plant cover is maintained; *w* shows that water in or on the soil interferes with plant growth or cultivation (in some soils the wetness can be partly corrected by artificial drainage); *s* shows that the soil is limited mainly because it is shallow, droughty, or stony; and *c*, used in only some parts of the United States, shows that the chief limitation is climate that is very cold or very dry.

In class I there are no subclasses because the soils of this class have few limitations. Class V contains only the subclasses indicated by *w, s,* or *c* because the soils in class V are subject to little or no erosion. They have other limitations that restrict their use to pasture, rangeland, woodland, wildlife habitat, or recreation.

The hectarage of soils in each capability class and subclass is shown in table 2. The capability classification of each map unit is given in the section "Detailed Soil Map Units."

Rangeland

About one-third of Guam is in savannah vegetation (*13*) and could be considered rangeland; however, very little of this land is actually grazed. In the past, cattle ranching was more important on Guam than at present. Most of the large operators have gone out of business or greatly reduced the size of their herds, primarily as a result of problems with cattle rustling. At present there are about 16 cattle or goat ranches on Guam that range in size from 3 to 5,000 hectares. Many subsistence farms have small numbers of cattle, goats, or carabao that use the range, often on tethers. In 1982 (*7*) there were about 1,400 cattle, 1,200 goats, and almost 400 carabao on the island.

The rangeland of Guam can be divided into three broad groupings based on the groupings used on the general soil map: Bottom lands, volcanic uplands, and limestone uplands.

The soils of the bottom lands (general soil map unit 1) consist dominantly of Inarajan soils. Most areas are either forested or farmed, and use of the land for grazing is relatively minor; however, it is locally very important. The dominant species are water-tolerant grasses such as paragrass (*Brachiaria mutica*), guineagrass (*Panicum maximum*), and *Paspalum* species. These are palatable grasses that provide excellent high protein forage (fig. 12). Tangantangan (*Leucaena leucocephala*) trees are present in some units, providing browse and shade.

Seasonal flooding and wetness are the main limitations of the soils on the bottom lands for range use. Animals should be removed when flooding occurs. Grazing when the soil is wet causes soil compaction and damages the range vegetation.

Because this unit is nearly level, intensive range management is practical. Cross-fencing could replace the labor-intensive tether system used by subsistence ranchers. Periodic mowing and dragging improve the range. Stock ponds can be developed. Conversion to improved pasture with fertilization followed by seeding with adapted legumes is also feasible. Adapted legumes include *Desmodium intortum*.

Figure 12.—Lush, palatable forage in an area of Inarajan soils in Umatac Valley. Agfayan soils in background support less palatable species.

The soils on the volcanic uplands (general soil map units 2 and 3) constitute the largest savannah areas on the island. These areas presently are underused and provide a large potential for range animals. The main grass species are swordgrass (*Miscanthus floridulus*), foxtail (*Pennisetum polystachyon*), and, in some areas, *Dimeria chloridiformis*. *Paspalum* species commonly are on Ylig soils. A number of forbs are also present, such as buttonweed (*Hyptis capitata*), ground orchid (*Spathoglottis plicata*), and false verbena (*Stachytarpheta spp.*). Shrubs and low trees are also common, particularly where the savannah grades into forest type vegetation.

Swordgrass, the dominant species in most places, is not palatable and is grazed as a last resort. Foxtail is quite palatable when young, although older plants are mostly stem and provide poor quality forage. Dimeria is a soft, palatable grass, but production is very low. Forbs and shrubs are not heavily used by cattle or carabao.

Limitations for range use include steepness of slope, wildfire, presence of unpalatable forage that has low protein value, and low soil fertility. Akina, Togcha, and Ylig soils provide the best opportunities for intensive rangeland management. Steepness of slope of the Agfayan and Akina soils limits access and requires that grazing units be larger. Wildfire destroys fences with wooden supports as well as livestock and promotes

erosion, which causes deterioration of the range. Overstocking, particularly on the steeper units, results in gully erosion along livestock trails and sheet erosion on side slopes. Overstocking eliminates palatable forage species on the range.

Management practices that reduce the percentage of swordgrass while increasing the percentage of foxtail, or introduced species, enhance the productivity of the range. One possible technique is to "prescribe burn" an area. When resprouting of the swordgrass occurs, use spot applications of herbicide to kill it. If not overgrazed, foxtail eventually becomes dominant. In nearly level to gently sloping areas, cultivation kills the swordgrass and spreads the foxtail.

Grazing animals must have access to water. Livestock watering ponds can be developed in low-lying areas of the Ylig soils.

Conversion to improved pasture is feasible in nearly level to gently sloping areas. After the existing undesirable vegetation has been destroyed, the range can be fertilized, limed where necessary, and seeded with adapted grasses and legumes. Adapted grasses include bahiagrass (*Paspalum notatum*). Adapted legumes include townsville stylo (*Stylosanthes humilis*) and centro (*Centrosema pubescens*) (*16*). If adequate fertilizer and lime are used, napiergrass (*Pennisetum purpureum*) or guineagrass (*Panicum maximum*) is suitable.

Soils on limestone uplands (general soil map units 4 through 8) generally are forested and have low potential for range use; however, there are important local areas of potential rangeland where the forest has been cleared. Guam soils are dominated by foxtail. Pulantat, Kagman, and Chacha soils support a mixture of foxtail, guineagrass, and, in places, Johnsongrass (*Sorghum halepense*). Tangantangan, which is present in all of these areas, provides some browse. Some abandoned military areas, particularly Northwest Field on Andersen Air Force Base, have some potential for use as rangeland. Ritidian soils are virtually all under native forest and are too steep or rough for grazing.

As previously discussed, foxtail provides high quality, palatable forage when young but deteriorates with age. Guineagrass is an excellent forage grass. Johnsongrass is toxic when young (*16*) and after moisture stress (*3*), and it should be avoided as forage or eliminated from range units. Tangantangan is a nutritous forage plant, although grazing animals should have access to grasses as well. Tangantangan interspersed among guineagrass or napiergrass provides excellent forage (*10*). Available forage can be increased by cutting the stem of tangantangan trees at a height of about 50 centimeters and periodically grazing the abundant shoot growth.

The main limitations for grazing on the soils that are underlain by limestone are the lack of available forage in the forested, steeply sloping areas and the droughtiness of the shallow soils. Kagman, Chacha, and Saipan soils are suitable for use as rangeland. Slopes are gentle, and the available water capacity is moderate. Guam cobbly clay loam also is well suited if the forest is cleared. Available water capacity of the Guam and Pulantat soils is very low, and forage production on them will be poor during the dry season. Cross-fencing and periodic mowing and dragging are good management practices for the soils that are not covered by rocks or are not too steep. These soils can also be converted to improved pasture by applying fertilizer and then seeding adapted grasses and legumes. Adapted legumes include *Calopogonium mucunoides*. Adapted grasses include guineagrass and napiergrass. Irrigation during the dry season improves forage production. Livestock watering ponds can be constructed successfully on the low-lying Chacha and Kagman soils.

Assistance with prescribed burning of rangeland is available from the Division of Forestry and Soil Resources, Department of Agriculture, Government of Guam. Assistance with ranch planning, range seeding, erosion control, and water management, including pond construction, is available from the local office of the Soil Conservation Service. Assistance with livestock production is available from the Cooperative Extension Service, College of Agriculture and Life Sciences, University of Guam.

Woodland Management and Productivity

Table 3 can be used by woodland owners or forest managers in planning the use of soils for wood crops and reforestation.

In table 3, *slight*, *moderate*, and *severe* indicate the degree of the major soil limitations to be considered in management.

Ratings of *equipment limitation* reflect the characteristics and conditions of the soil that restrict use of the equipment generally needed in woodland management or harvesting. A rating of *slight* indicates that use of equipment is not limited to a particular kind of equipment or time of year; *moderate* indicates a short seasonal limitation or a need for some modification in management or in equipment; and *severe* indicates a seasonal limitation, a need for special equipment or management, or a hazard in the use of equipment.

Seedling mortality ratings indicate the degree to which the soil affects the mortality of tree seedlings. Plant competition is not considered in the ratings. The ratings apply to seedlings from good stock that are properly planted during a period of sufficient rainfall. A rating of *slight* indicates that the expected mortality is less than 25 percent; *moderate*, 25 to 50 percent; and *severe*, more than 50 percent.

Ratings of *windthrow hazard* are based on soil characteristics that affect the development of tree roots and the ability of the soil to hold trees firmly. A rating of *slight* indicates that few trees may be blown down by

strong winds; *moderate*, that some trees will be blown down during periods of excessive soil wetness and strong winds; and *severe*, that many trees are blown down during periods of excessive soil wetness and moderate or strong winds.

Ratings of *plant competition* indicate the degree to which undesirable plants are expected to invade where there are openings in the tree canopy. The invading plants compete with native plants or planted seedlings. A rating of *slight* indicates little or no competition from other plants; *moderate* indicates that plant competition is expected to hinder the development of a fully stocked stand of desirable trees; *severe* indicates that plant competition is expected to prevent the establishment of a desirable stand unless the site is intensively prepared, weeded, or otherwise managed to control undesirable plants.

Commonly grown trees are those that occur naturally in forested areas of the map unit. The list is a general guide and may not accurately represent the composition of species at any particular site.

Trees to plant are those that are suited to the soils and to rapid forest regeneration under a relatively low level of management. Commercially valuable trees, such as fruit trees, can also be grown but they grow slowly and require more care.

About 38 percent of Guam is forested. Most of the forested soils formed in sediment overlying limestone. A long history of island settlement combined with more recent urbanization, fire, agricultural development, and World War II have all contributed to greatly alter Guam's forests and to reduce their extent. Potential for commercial timber production on Guam is low, primarily because of the frequency with which typhoons strike the island. Water deficits during the dry season probably restrict the growth rate of potential commercial species.

The forests in Guam are used by man primarily for recreation, hunting, and as a source of firewood, food, and medicinal and handicraft material. Preferred firewood species include tangantangan (*Leucaena leucocephala*) and dead ifil (*Intsia bijuga*). Important food species include the coconut palm (*Cocos nucifera*), breadfruit (*Artocarpus altilis*), various yams (*Dioscorea spp.*), mango (*Mangifera indica*), and many others. Suruhanos, or traditional healers, are active and important in Guam, and they use many forest species. Handicraft and traditional uses of forest products include weaving of baskets and hats from pandanus and coconut leaves, cutting of thatch and poles for temporary shelters, carving of ifilwood for furniture and curios, and production of perfume from ilangilang (*Cananga odorata*) flowers.

The characteristics of Guam's forests vary from place to place because of the influence of such factors as kind of soil, topographic position, degree of disturbance, and seed source. Reasons for forest variability and distribution are complex and controversial. Various forest classification systems can be used. This discussion approaches forest variability on the basis of differences in soils. The brief descriptions that follow give only the most common tree species; additional information can be found in works by Fosberg (*5*), Stone (*18*), and Moore and McMakin (*9*). For accuracy, the scientific names of plant species are used. Figure 13 lists all species referred to in this section by scientific name and by English and Chamorro common names. Scientific names follow Fosberg and others (*6*) and Stone (*18*).

The most diverse and well-developed forest occurs primarily on soils such as those of the Guam, Yigo, and Ritidian series. It also occurs on Pulantat, Kagman, and Saipan soils, although these areas have largely given way to *Leucaena leucocephala*. Dominant trees include *Artocarpus mariannensis*, *Pisonia grandis*, *Ficus prolixa*, *Merrilliodendron megacarpum*, *Tristiropsis obtusangula*, *Mammea odorata*, and *Elaeocarpus sphaericus*. Subdominant trees include *Pandanus tectorius* and *P. dubius*, *Aglaia mariannensis*, *Guamia mariannae*, *Cycas circinalis*, *Neiosperma oppositifolia*, *Macaranga thompsonii*, and many others. An introduced tree, *Vitex parviflora*, is dominant in many areas. The only tree of commercial value in the limestone forest is *Intsia bijuga*, which is currently used for hand-carved furniture and handicrafts. It is a slow-growing tree, however, and most large individuals have been harvested, but numerous small-stemmed trees are widespread, assuring future prevalence.

Forest also occurs intermittently on volcanic soils such as those of the Akina, Atate, and Agfayan series. It commonly occurs on lower and leeward slopes but may occur on ridgelines as well. This forest differs from the forest on soils that formed in sediment overlying limestone in that the number of species is greatly restricted. Certain species such as *Guamia mariannae*, *Aglaia mariannensis*, *Intsia bijuga*, and *Ficus prolixa* are seldom encountered. Common trees of the volcanic forest include *Hibiscus tiliaceus*, *Pandanus fragrans*, *Areca cathechu*, *Calophyllum inophyllum*, *Glochidion marianum*, *Canaga odorata*, and occasionally *Barringtonia racemosa*. *Casuarina equisetifolia* is common on volcanic soils but is commonly associated with savannah vegetation. Tree species on volcanic soils, particularly *Casuarina*, are probably restricted in extent by fires. The surface layer of areas of Akina and Atate soils under forest is less acid than is typical for areas of these soils under savannah vegetation. Betelnuts are harvested from wild *Areca* palms, but such forests are seldom used for wood products.

The forest that occurs on Inarajan soils is restricted to tree species that can tolerate intermittent flooding and wetness. These species include *Hibiscus tiliaceus*, *Pandanus tectorius*, scattered *Barringtonia racemosa*,

Figure 13.--List of scientific and common plant names

Scientific name	Common name	
	English	Chamorro
Acacia auriculiformis	sickle-leaf acacia	none
Acacia confusa	Formosa acacia	none
Acacia mangium	broad-leaved acacia	none
Aglaia mariannensis	none	mapunao
Albizia falcateria	none	none
Albizia lebbek	none	manu's
Araucaria heterophylla	Norfolk-Island pine	none
Areca cathechu	betelnut	pugu', ugu'm
Artocarpus altilis	breadfruit	lemai
Artocarpus mariannensis	seeded breadfruit	dugdug
Bambusa vulgarus	bamboo	pi'ao
Barringtonia asiatica	fish-kill tree	putting
Barringtonia racemosa	none	langasat
Calophyllum inophyllum	palomaria	da'og
Cananga odorata	none	ilangilang
Casuarina equisetifolia	Australian pine, ironwood	gago
Catalpa longissima	yokewood	none
Cedrela odorata	Spanish cedar	none
Cerbera dilatata	none	chiute
Cocos nucifera	coconut palm	niyog
Cordia subcordata	none	niyoron
Cycas circinalis	Federico palm	fadang
Dioscorea spp.	yam	dago, nika
Elaeocarpus sphaericus	none	yoga
Enterolobium cylocarpum	earpod	none
Eucalyptus deglupta	eucalyptus	none
Eucalyptus camaldulensis	eucalyptus	none
Eucalyptus pellita	eucalyptus	none
Eucalyptus gomphocephala	eucalyptus	none
Eucalyptus jensenii	eucalyptus	none
Eucalyptus tereicornis	eucalyptus	none
Eucalyptus urophylla	eucalyptus	none
Eugenia thompsonii	eucalyptus	atoto
Ficus prolixa	banyan	nunu
Ficus tinctoria	none	hotda
Glochidion marianum	none	chosga
Gmelina arborea	melyna	none
Grevillea robusta	silk-oak	none
Guamia mariannae	none	paipai
Guettarda speciosa	none	panao
Hertiera littoralis	none	ufa
Hernandia sonora	none	nonak
Heterospathe elata	palma brava	none
Hibiscus tiliaceus	sea hibiscus	pago

Figure 13.--List of scientific and common plant names--continued

Scientific name	Common name	
	English	Chamorro
Intsia bijuga	Moluccan ironwood	ifil
Leucaena leucocephala	tangantangan	talantayan
Mammea odorata	none	chopak
Mangifera indica	mango	mangga
Merrilliodendron megacarpum	none	faniok
Neiosperma oppositifolia	none	fago
Pandanus dubius	screw pine	pahong
Pandanus tectorius	screw pine	kafu
Peltophorum pterocarpum	cooperpod	none
Phragmites karka	cane	kariso
Pisonia grandis	none	none
Pithecellobium dulce	Manila tamarind	kamachile
Premna obtusifolia	none	ahgao
Pterocarpus indicus	none	narra
Samanea saman	monkeypod	none
Swietenia macrophylla	Honduran mahogany	none
Tectona grandis	teak	none
Terminalia catalpa	tropical almond	talisai
Thespesia populnea	none	binalo
Tournefortia argentea	none	hunek
Tristiropsis obtusangula	none	faia
Vitex parviflora	none	lagundi

and *Leucaena leucocephala*. Inarajan Variant soils support mangroves in a few coastal areas. *Phragmites karka* is a common understory component, and bamboo (*Bambusa vulgarus*) is common along streambanks. Bamboo is occasionally used for construction of temporary shelters and huts, but no other wood products are used from these forests.

The forest species on Shioya soils are tolerant of salinity. Tree species include *Casuarina equisetifolia*, *Thespesia populnea*, *Pandanus fragrans* and *P. dubius*, *Tournefortia argentea*, *Hernandia sonora*, *Barringtonia asiatica*, *Guettarda speciosa*, *Cocos nucifera*, *Terminalia catalpa*, *Calophyllum inophyllum*, and *Leucaena leucocephala*. This forest is used extensively for recreation, and a few coconuts are harvested for home consumption, but no wood products are used.

A forest dominated by the introduced palm *Heterospathe elata* occurs in central Guam, primarily on the Agfayan soils, and appears to be spreading. This palm also grows on Pulantat, Akina, and Atate soils. The surface layer in areas of the Akina and Atate soils under this palm forest is less acid than is typical of areas of these kinds of soil that are under savannah vegetation. As in other forests that grow on volcanic soils, this palm forest generally occupies the lower slopes and more protected positions, but it also occurs on ridgelines in some areas. Species composition is mixed and variable, but it usually includes *Hibiscus tiliaceus* and *Cananga odorata*. The dominant tree is *Heterospathe elata*. The reasons for its limited distribution are not clear, but they probably are related to seed source. The relationship of this palm forest to kinds of soil bears further investigation. No use is made of wood products from these forests.

Tangantangan (*Leucaena leucocephala*) grows in thick stands in disturbed areas of the Pulantat, Chacha, Kagman, and Saipan soils. It also grows in disturbed areas of Guam and Shioya soils. This is an exotic species that was introduced many years ago. Its widespread occurrence in Guam is attributed to aerial broadcast following the devastation of World War II. It is considered to be a reliable indicator of high calcium soil conditions, such as those in limestone soils, where it forms almost pure stands of small-stemmed trees. Other limestone forest species that are present in some areas are species of *Guamia* and *Ficus*. Tangantangan wood is used extensively for firewood, as poles and trellises for a variety of vegetable crops, and as posts for temporary shelters and huts. Trees may reach 20 meters in height and have a diameter of as much as 20 centimeters, although 10 centimeters is more common. This forest type is not managed for higher productivity; however, thinning to a spacing of about 1 meter would improve the size of the trees and perhaps increase their utility. After the tree is cut, the stump produces abundant coppice growth.

To produce additional poles or firewood, the dominant shoot should be allowed to grow and the others pruned off. After a few years, additional poles can be harvested. Tangantangan forest can also be managed for use as grazing land.

Forestation and Type Conversion

By Dr. William Null, Territorial Forester, Division of Forestry and Soil Resources, Department of Agriculture, Government of Guam.

There is a severe erosion problem on the volcanic soils of southern Guam. Akina and Atate soils are particularly subject to erosion. Togcha, Agfayan, and Sasalaguan soils are also actively eroding in some areas. Badlands are formed when Akina and Atate soils are eroded so severely that natural revegetation does not occur.

Wildfires are prevalent on the savannahs of Guam. These wildfires destroy vast areas of plant cover on volcanic soils every dry season. Natural regrowth is often slow and incomplete because of moisture stress. Presence of plant cover is a crucial factor in controlling soil erosion. If high-intensity storms occur when the soil is bare, as is the case after a wildfire, massive erosion can result.

For more than 10 years the Forestry and Soil Resources Division of the Guam Department of Agriculture has endeavored to convert the fire-prone savannah vegetation to less flammable forest vegetation. The main objective has been to reduce the incidence and spread of wildfires, which ultimately cause soil erosion. In order to reach this objective, it is important to find tree species that tolerate fire and grow well on the seasonally dry Akina and Atate soils. The division has found a few potential tree species and also developed a technique for stand establishment that shows promise.

Swordgrass (*Miscanthus floridulus*) is the dominant plant on the savannahs and is the main fuel for wildfires. Swordgrass also competes effectively with trees and therefore must be eliminated from a site that is to be converted to forest. Various methods have been tried, but only one to date, although expensive, is considered to be cost effective. The Forestry and Soil Resources Division is still seeking ways, however, to reduce the establishment costs without sacrificing effectiveness. The method employed is to take advantage of an already burned area or to intentionally burn the proposed area. About 4 to 6 weeks after the burn, new growth of swordgrass has developed sufficiently to accept and translocate a systemic herbicide. The whole area is then liberally sprayed with the chemical glyphosate, which provides the most effective control of swordgrass. Anytime after 3 days following this spraying, the area is then marked off for the next procedural step—ripping. The ripper employed is a standard tractor-drawn implement that can fracture the compact clay soils to a depth of 75 centimeters. Planting can follow immediately or be withheld to allow the entry of water and any organic matter that is available at the surface.

Tree spacing depends upon the distance between ripped lines and the distance apart that seedlings are to be planted within the rows (ripped lines). The Forestry Division uses a spacing of 3 meters by 2 meters (3 meters between rows and 2 meters within rows) for their conservation-type conversion plantings, and a much denser 1 meter by 1 meter spacing in their demonstration biomass plantings. Nursery stock is grown exclusively in containers; 95 percent of the stock is rooted in small tubes containing a medium composed of cut sphagnum moss and vermiculite. The seedlings of the remaining 5 percent are grown in a soil base medium in plastic bags that can accommodate the large seeded species. When planting seedlings in the ripped lines, a worker needs only to make a few thrusts with a planting tool to create a cavity, add 30 cubic centimeters of slow-release fertilizer, place the seedling into the hole, cover with soil, and then firm up the soil with applied foot pressure. Field mortality has been minimal—less than 5 percent with acacia species and less than 10 percent with all other species grown in the Guam Forest Nursery.

Subsequent maintenance of these planted seedlings entails the removal of competing vegetation by periodic tractor mowing between the rows and individual ring weeding, if needed. This mowing maintenance is necessary for the first 2 years, after which time crown closure keeps the competition under control. Growth rates vary with species and site characteristics. As a general rule, both *Acacia auriculiformis* and *A. mangium*, as well as the species of eucalyptus (see fig. 13), should exceed 2 meters in height 1 year after planting and 4 meters after 2 years. Three years after

outplanting, these species should exceed 7 meters in height and 15 centimeters in diameter at breast height. At this point there should be sufficient crown closure to keep grass and other undesirable vegetation from competing effectively. The growth rate of other species, except for *Gmelina arborea* on the Yigo and Chacha soils, is somewhat less than that given above. One can expect, however, to have trees reach a height of 8 meters and a diameter of 20 centimeters at breast height within 5 years. The growth of *Gmelina arborea* on nonacid soils is very much like that of the aforementioned acacias and eucalyptuses.

Windbreaks and Environmental Plantings

Windbreaks can be used very effectively in exposed locations on Guam. Properly designed windbreaks reduce wind damage to young crops and reduce the loss of moisture through evapotranspiration. Such moisture loss can be particularly significant in areas of the very shallow, droughty Guam cobbly clay loam on the exposed northern plateau.

During the dry season the trade winds blow primarily from the east and northeast; however, passing tropical storms create crop-damaging winds that may come from any direction. For this reason, windbreaks are recommended around the entire perimeter of fields. Windbreaks offer protection in an area only about 10 times as long as their height. Wind protection is a factor to be considered when designing field size.

In addition to exposed farm fields, coastal areas with northerly or easterly exposures can also benefit from the use of windbreaks. Plant materials must be able to withstand salt spray.

Unfortunately, windbreaks will not protect crops or property from typhoon-force winds.

Table 4 shows the height that locally grown trees and shrubs are expected to reach in 20 years on various soils. The estimates in table 4 are based on measurements and observations of established plantings that have been given adequate care. They can be used as a guide in planning windbreaks and screens.

Following are additional plants that are suitable for use in windbreaks and the maximum height some of them can be expected to reach: napiergrass and hibiscus, 2.5 meters; pigeon pea, 3 meters; wild sugarcane, 4 meters; lalangita, 5.5 meters; tangantangan (not suited on the Akina, Atate, and Togcha soils), and avocado, 7.5 meters; sickle-leaf acacia, and broad-leaved acacia, 9 meters; and *Eucalyptus camaldulensis* and *gomphocephala*.

Assistance in designing windbreaks can be obtained at the local office of the Soil Conservation Service or the Division of Forestry and Soil Resources, Department of Agriculture, Government of Guam.

Recreation

Recreational use of Guam's landscape is increasing rapidly along with the tourist industry and the growing urban population. Picnic facilities in the coastal areas, particularly on Shioya soils, receive heavy use. Public and tourist demand will undoubtedly result in further recreational development, both public and private, in coastal areas. The rugged mountains in southern Guam provide good hiking and sightseeing opportunities, particularly where trails lead to waterfalls and remote beaches. Off-road vehicle recreation is also popular in this area.

The potential for recreational development is high, but certain natural soil and climate limitations must be considered. Many coastal areas are Inarajan soils, which have low load supporting capacity and are subject to flooding. Shioya soils are close to the ocean, and any structures built on them should be designed to withstand high winds and waves. The scenic southern mountains are steep, and the Akina soils in these areas are subject to slumping. Improperly designed roads and trails are quickly gullied. At present, there are no properly designed hiking trails in southern Guam. The extensive areas of Badland in the Dandan Basin, along Cross-Island Road, and elsewhere are well suited to off-road vehicle recreation; however, traffic must be controlled to prevent degradation of surrounding vegetated areas and conservation plantings. Use of farm and ranch access roads by recreational off-road vehicles should be discouraged because of the low strength of the soils.

The soils of the survey area are rated in table 5 according to limitations that affect their suitability for recreation. The ratings are based on restrictive soil features such as wetness, slope, and texture of the surface layer. Susceptibility to flooding is considered. Not considered in the ratings, but important in evaluating a site, are the location and accessibility of the area, the size and shape of the area and its scenic quality, vegetation, access to water, potential water impoundment sites, and access to public sewerlines. The capacity of the soil to absorb septic tank effluent and the ability of the soil to support vegetation are also important. Soils subject to flooding are limited for recreational use by the duration and intensity of flooding and the season when flooding occurs. In planning recreational facilities, onsite assessment of the height, duration, intensity, and frequency of flooding is essential.

In table 5, the degree of soil limitation is expressed as slight, moderate, or severe. *Slight* means that soil properties generally are favorable and that limitations are minor and easily overcome. *Moderate* means that limitations can be overcome or alleviated by planning, design, or special maintenance. *Severe* means that soil properties are unfavorable and that limitations can be offset only by costly soil reclamation, special design,

intensive maintenance, limited use, or by a combination of these measures.

The information in table 5 can be supplemented by other information in this survey; for example, interpretations for dwellings without basements and for local roads and streets in table 7 and interpretations for septic tank absorption fields in table 8.

Camp areas require site preparation such as shaping and leveling the tent and parking areas, stabilizing roads and intensively used areas, and installing sanitary facilities and utility lines. Camp areas are subject to heavy foot traffic and some vehicular traffic. The best soils are nearly level or gently sloping and they are not wet or subject to flooding during the period of use. The surface has few or no stones or boulders, absorbs rainfall readily but remains firm, and is not dusty when dry. Steep slopes and stones or boulders can greatly increase the cost of constructing campsites.

Picnic areas are subject to heavy foot traffic. Most vehicular traffic is confined to access roads and parking areas. The best soils for picnic areas are firm when wet, are not dusty when dry, are not subject to flooding during the period of use, and do not have slopes or stones or boulders that increase the cost of shaping sites or of building access roads and parking areas.

Playgrounds require soils that can withstand intensive foot traffic. The best soils are almost level and are not wet or subject to flooding during the season of use. The surface is free of stones and boulders, is firm after rains, and is not dusty when dry. If grading is needed, the depth of the soil over bedrock or a hardpan should be considered.

Paths and trails for hiking and horseback riding should require little or no cutting and filling. The best soils are not wet, are firm after rains, are not dusty when dry, and are not subject to flooding more than once a year during the period of use. They have moderate slopes and few or no stones or boulders on the surface.

Golf fairways are subject to heavy foot traffic and some light vehicular traffic. Cutting or filling may be required. The best soils for use as golf fairways are firm when wet, are not dusty when dry, and are not subject to prolonged flooding during the period of use. They have moderate slopes and no stones or boulders on the surface. The suitability of the soil for tees or greens is not considered in rating the soils.

Wildlife Habitat

Information in this section was provided by the Division of Aquatic and Wildlife Resources, Department of Agriculture, Government of Guam.

Wildlife on Guam has been greatly affected and altered by the introduction of exotic species. All of the large mammals have been introduced onto the island by man. The Guam deer was introduced by the Spanish in 1770. The carabao, or water buffalo, is another Spanish introduction. Carabao were originally used as domestic animals for farming and hauling, and many animals are still retained by local families. Domestic pigs have gone wild and, over the generations, reverted back to their original form, which are now recognizable as the wild boar. The black frankolin, which was introduced from India in 1961, is now the major upland game bird in southern Guam.

The once-abundant birdlife on the island is now greatly restricted in extent. Some species, such as the Guam broadbill, the bridled white-eye, and the rufous-fronted fantail, have virtually disappeared from the island. Other native forest birds such as the Guam rail, Micronesian kingfisher, Marianas crow, cardinal honeyeater, white-throated ground dove, and Marianas fruit dove are nearing extinction. Recent work indicates that predation, mainly by the introduced brown tree snake, is a major cause for this decline; however, other factors may be involved.

The Marianas fruit bat is one of the few native mammals. Once abundant in Guam's forests, the fruit bat was hunted for food in the past. It is now an endangered species on Guam, and it lives mainly in the northern forest, on Andersen Air Force Base.

Another native Guamanian species that is still used for food is the coconut crab. The coconut crab is abundant near the coast, primarily on the Shioya and Inarajan soils.

Other wildlife species on Guam include the monitor lizard, numerous skinks and geckos, the giant marine toad, and the blind snake.

Savannah fires of southern Guam affect different wildlife species in different ways. Fire destroys active nests of savannah birds, such as the black francolin, blue-breasted quail, and yellow bittern. Fire also destroys forests that provide cover for mammals and habitat for many birds. On the other hand, fire consumes dry, low-quality forage and promotes lush new growth that is highly palatable to mammals.

Soils affect the kind and amount of vegetation that is available to wildlife as food and cover. They also affect the construction of water impoundments. The kind and abundance of wildlife depend largely on the amount and distribution of food, cover, and water. Wildlife habitat can be created or improved by planting appropriate vegetation, by maintaining the existing plant cover, or by promoting the natural establishment of desirable plants.

In table 6, the soils in the survey area are rated according to their potential for providing habitat for various kinds of wildlife. This information can be used in planning parks, wildlife refuges, nature study areas, and other developments for wildlife; in selecting soils that are suitable for establishing, improving, or maintaining specific elements of wildlife habitat; and in determining the intensity of management needed for each element of the habitat.

The potential of the soil is rated good, fair, poor, or very poor. A rating of *good* indicates that the element or kind of habitat is easily established, improved, or maintained. Few or no limitations affect management, and satisfactory results can be expected. A rating of *fair* indicates that the element or kind of habitat can be established, improved, or maintained in most places. Moderately intensive management is required for satisfactory results. A rating of *poor* indicates that limitations are severe for the designated element or kind of habitat. Habitat can be created, improved, or maintained in most places, but management is difficult and must be intensive. A rating of *very poor* indicates that restrictions for the element or kind of habitat are very severe and that unsatisfactory results can be expected. Creating, improving, or maintaining habitat is impractical or impossible.

The elements of wildlife habitat are described in the following paragraphs.

Wild herbaceous plants are native or naturally established grasses and forbs, including weeds. Soil properties and features that affect the growth of these plants are depth of the root zone, texture of the surface layer, available water capacity, wetness, surface stoniness, and flood hazard. Soil moisture is also a consideration. Examples of wild herbaceous plants are foxtail, dimeria, guineagrass, momordica, and calopogonium.

Hardwood trees and woody understory produce nuts or other fruit, buds, catkins, twigs, bark, and foliage. Soil properties and features that affect the growth of hardwood trees and shrubs are depth of the root zone, the available water capacity, and wetness. Examples of these plants are pandanus, morinda, breadfruit, soursop, papaya, panama cherry, and hernandia. Examples of fruit-producing shrubs that are suitable for planting on soils rated *good* are sour plum, Surinam cherry, and Tahitian gooseberry.

Shrubs are bushy woody plants that produce fruit, buds, twigs, bark, and foliage. Soil properties and features that affect the growth of shrubs are depth of the root zone, available water capacity, salinity, and soil moisture. Examples of shrubs are guava, cestrum, triphasia, and glochidion.

Wetland plants are annual and perennial wild herbaceous plants that grow on moist or wet sites. Submerged or floating aquatic plants are excluded. Soil properties and features affecting wetland plants are texture of the surface layer, wetness, reaction, salinity, slope, and surface stoniness. Examples of wetland plants are brachiaria, kariso, taro, sedges, and reeds.

Shallow water areas are areas of surface water with average depth of less than 150 centimeters. Some are naturally wet areas. Others are created by dams, levees, or other water-control structures. Soil properties and features affecting shallow water areas are depth to bedrock, wetness, surface stoniness, slope, and permeability. Examples of shallow water areas are marshes, waterfowl feeding areas, and ponds.

The habitat for various kinds of wildlife is described in the following paragraphs.

Habitat for openland wildlife consists of cropland, pasture, meadows, and areas that are overgrown with grasses, herbs, shrubs, and vines. These areas produce grasses, legumes, and wild herbaceous plants. The wildlife attracted to these areas include carabao, deer, pig, black francolin, blue-breasted quail, yellow bittern, chestnut mannikin, eurasian tree sparrow, and Guam rail.

Habitat for woodland wildlife consists of areas of forests and shrubs and associated grasses, legumes, and wild herbaceous plants. Wildlife attracted to these areas include pig, deer, carabao, monitor lizard, brown tree snake, and birds such as the Marianas crow, Guam rail, Micronesian kingfisher, and cardinal honeyeater.

Habitat for wetland wildlife consists of open, marshy or swampy shallow water areas. Some of the wildlife attracted to such areas are migrant ducks, shore birds, carabao, pig, deer, yellow bittern, and Marianas gallinule.

Engineering

This section provides information for planning land uses related to urban development and to water management. Soils are rated for various uses, and the most limiting features are identified. The ratings are given in the following tables: Building Site Development, Sanitary Facilities, Construction Materials, and Water Management. The ratings are based on observed performance of the soils and on the estimated data and test data in the "Soil Properties" section.

Information in this section is intended for land use planning, for evaluating land use alternatives, and for planning site investigations prior to design and construction. The information, however, has limitations. For example, estimates and other data generally apply only to that part of the soil within a depth of 150 centimeters. Because of the map scale, small areas of different soils may be included within the mapped areas of a specific soil.

The information is not site specific and does not eliminate the need for onsite investigation of the soils or for testing and analysis by personnel experienced in the design and construction of engineering works.

Government ordinances and regulations that restrict certain land uses or impose specific design criteria were not considered in preparing the information in this section. Local ordinances and regulations need to be considered in planning, in site selection, and in design.

Soil properties, site features, and observed performance were considered in determining the ratings in this section. During the fieldwork for this soil survey, determinations were made about grain-size distribution, liquid limit, plasticity index, soil reaction, depth to bedrock, hardness of bedrock within 150 centimeters of

the surface, soil wetness, depth to a seasonal high water table, slope, likelihood of flooding, natural soil structure aggregation, and soil density. Data were collected about kinds of clay minerals, mineralogy of the sand and silt fractions, and the kind of adsorbed cations. Estimates were made for erodibility, permeability, corrosivity, shrink-swell potential, available water capacity, and other behavioral characteristics affecting engineering uses.

This information can be used to (1) evaluate the potential of areas for residential, commercial, industrial, and recreation uses; (2) make preliminary estimates of construction conditions; (3) evaluate alternative routes for roads, streets, highways, pipelines, and underground cables; (4) evaluate alternative sites for sanitary landfills, septic tank absorption fields, and sewage lagoons; (5) plan detailed onsite investigations of soils and geology; (6) locate potential sources of gravel, sand, earthfill, and topsoil; (7) plan drainage systems, irrigation systems, ponds, terraces, and other structures for soil and water conservation; and (8) predict performance of proposed small structures and pavements by comparing the performance of existing similar structures on the same or similar soils.

The information in the tables, along with the soil maps and soil descriptions, and other data provided in this survey can be used to make additional interpretations.

Some of the terms used in this soil survey have a special meaning in soil science and are defined in the Glossary.

Building Site Development

Table 7 shows the degree and kind of soil limitations that affect shallow excavations, dwellings with and without basements, small commercial buildings, local roads and streets, and lawns and landscaping. The limitations are considered *slight* if soil properties and site features generally are favorable for the indicated use and limitations are minor and easily overcome; *moderate* if soil properties or site features are not favorable for the indicated use and special planning, design, or maintenance is needed to overcome or minimize the limitations; and *severe* if soil properties or site features are so unfavorable or so difficult to overcome that special design, significant increases in construction costs, and possibly increased maintenance are required. Special feasibility studies may be required where the soil limitations are severe.

Shallow excavations are trenches or holes dug to a maximum depth of 150 centimeters for basements, graves, utility lines, open ditches, and other purposes. The ratings are based on soil properties, site features, and observed performance of the soils. The ease of digging, filling, and compacting is affected by the depth to bedrock, a cemented pan, or a very firm dense layer; stone content; soil texture; and slope. The time of the year that excavations can be made is affected by the depth to a seasonal high water table and the susceptibility of the soil to flooding. The resistance of the excavation walls or banks to sloughing or caving is affected by soil texture and the depth to the water table.

Dwellings and small commercial buildings are structures built on shallow foundations on undisturbed soil. The load limit is the same as that for single-family dwellings no higher than three stories. Ratings are made for small commercial buildings without basements and for dwellings without basements. The ratings are based on soil properties, site features, and observed performance of the soils. A high water table, flooding, shrink-swell potential, and organic layers can cause the movement of footings. A high water table, depth to bedrock or to a cemented pan, large stones, and flooding affect the ease of excavation and construction. Landscaping and grading that require cuts and fills of more than 150 centimeters are not considered.

Local roads and streets have an all-weather surface and carry automobile and light truck traffic all year. They have a subgrade of cut or fill soil material, a base of gravel, crushed rock, or stabilized soil material, and a flexible or rigid surface. Cuts and fills generally are limited to less than 180 centimeters. The ratings are based on soil properties, site features, and observed performance of the soils. Depth to bedrock or to a cemented pan, a high water table, flooding, large stones, and slope affect the ease of excavating and grading. Soil strength (as inferred from the engineering classification of the soil), shrink-swell potential, frost action potential, and depth to a high water table affect the traffic supporting capacity.

Lawns and landscaping require soils on which turf and ornamental trees and shrubs can be established and maintained. The ratings are based on soil properties, site features, and observed performance of the soils. Soil reaction, a high water table, depth to bedrock or to a cemented pan, the available water capacity in the upper 100 centimeters, and the content of salts, sodium, and sulfidic materials affect plant growth. Flooding, wetness, slope, stoniness, and the amount of sand, clay, or organic matter in the surface layer affect trafficability after vegetation is established.

Sanitary Facilities

Table 8 shows the degree and the kind of soil limitations that affect septic tank absorption fields, sewage lagoons, and sanitary landfills. The limitations are considered *slight* if soil properties and site features generally are favorable for the indicated use and limitations are minor and easily overcome; *moderate* if soil properties or site features are not favorable for the indicated use and special planning, design, or maintenance is needed to overcome or minimize the limitations; and *severe* if soil properties or site features are so unfavorable or so difficult to overcome that

special design, significant increases in construction costs, and possibly increased maintenance are required.

Table 8 also shows the suitability of the soils for use as daily cover for landfills. A rating of *good* indicates that soil properties and site features are favorable for the use and good performance and low maintenance can be expected; *fair* indicates that soil properties and site features are moderately favorable for the use and one or more soil properties or site features make the soil less desirable than the soils rated good; and *poor* indicates that one or more soil properties or site features are unfavorable for the use and overcoming the unfavorable properties requires special design, extra maintenance, or costly alteration.

Septic tank absorption fields are areas in which effluent from a septic tank is distributed into the soil through subsurface tiles or perforated pipe. Only that part of the soil between depths of 60 and 180 centimeters is evaluated. The ratings are based on soil properties, site features, and observed performance of the soils. Permeability, a high water table, depth to bedrock or to a cemented pan, and flooding affect absorption of the effluent. Large stones and bedrock or a cemented pan interfere with installation.

Unsatisfactory performance of septic tank absorption fields, including excessively slow absorption of effluent, surfacing of effluent, and hillside seepage, can affect public health. Ground water can be polluted if highly permeable sand and gravel or fractured bedrock is less than 120 centimeters below the base of the absorption field, if slope is excessive, or if the water table is near the surface. There must be unsaturated soil material beneath the absorption field to filter the effluent effectively. Many local ordinances require that this material be of a certain thickness.

Sewage lagoons are shallow ponds constructed to hold sewage while aerobic bacteria decompose the solid and liquid wastes. Lagoons should have a nearly level floor surrounded by cut slopes or embankments of compacted soil. Lagoons generally are designed to hold the sewage within a depth of 60 to 150 centimeters. Nearly impervious soil material for the lagoon floor and sides is required to minimize seepage and contamination of ground water.

Table 8 gives ratings for the natural soil that makes up the lagoon floor. The surface layer and, generally, 30 to 60 centimeters of soil material below the surface layer are excavated to provide material for the embankments. The ratings are based on soil properties, site features, and observed performance of the soils. Considered in the ratings are slope, permeability, a high water table, depth to bedrock or to a cemented pan, flooding, large stones, and content of organic matter.

Excessive seepage because of rapid permeability of the soil or a water table that is high enough to raise the level of sewage in the lagoon causes a lagoon to function unsatisfactorily. Pollution results if seepage is excessive or if floodwater overtops the lagoon. A high content of organic matter is detrimental to proper functioning of the lagoon because it inhibits aerobic activity. Slope, bedrock, and cemented pans can cause construction problems, and large stones can hinder compaction of the lagoon floor.

Sanitary landfills are areas where solid waste is disposed of by burying it in soil. There are two types of landfill—trench and area. In a trench landfill, the waste is placed in a trench. It is spread, compacted, and covered daily with a thin layer of soil excavated at the site. In an area landfill, the waste is placed in successive layers on the surface of the soil. The waste is spread, compacted, and covered daily with a thin layer of soil from a source away from the site.

Both types of landfill must be able to bear heavy vehicular traffic. Both types involve a risk of ground water pollution. Ease of excavation and revegetation needs to be considered.

The ratings in table 8 are based on soil properties, site features, and observed performance of the soils. Permeability, depth to bedrock or to a cemented pan, a high water table, slope, and flooding affect both types of landfill. Texture, stones and boulders, highly organic layers, soil reaction, and content of salts and sodium affect trench type landfills. Unless otherwise stated, the ratings apply only to that part of the soil within a depth of about 180 centimeters. For deeper trenches, a limitation rated slight or moderate may not be valid. Onsite investigation is needed.

Daily cover for landfill is the soil material that is used to cover compacted solid waste in an area type sanitary landfill. The soil material is obtained offsite, transported to the landfill, and spread over the waste.

Soil texture, wetness, coarse fragments, and slope affect the ease of removing and spreading the material during wet and dry periods. Loamy or silty soils that are free of large stones or excess gravel are the best cover for a landfill. Clayey soils are sticky or cloddy and are difficult to spread; sandy soils are subject to wind erosion.

After soil material has been removed, the soil material remaining in the borrow area must be thick enough over bedrock, a cemented pan, or the water table to permit revegetation. The soil material used as final cover for a landfill should be suitable for plants. The surface layer generally has the best workability, more organic matter, and the best potential for plants. Material from the surface layer should be stockpiled for use as the final cover.

Construction Materials

Table 9 gives information about the soils as a source of roadfill, sand, gravel, and topsoil. The soils are rated *good, fair,* or *poor* as a source of roadfill and topsoil. They are rated as a probable or improbable source of

sand and gravel. The ratings are based on soil properties and site features that affect the removal of the soil and its use as construction material. Normal compaction, minor processing, and other standard construction practices are assumed. Each soil is evaluated to a depth of 150 centimeters.

Roadfill is soil material that is excavated in one place and used in road embankments in another place. In this table, the soils are rated as a source of roadfill for low embankments, generally less than 180 centimeters high and less exacting in design than higher embankments.

The ratings are for the soil material below the surface layer to a depth of 150 centimeters. It is assumed that soil layers will be mixed during excavating and spreading. Many soils have layers of contrasting suitability within their profile. The table showing engineering index properties provides detailed information about each soil layer. This information can help determine the suitability of each layer for use as roadfill. The performance of soil after it is stabilized with lime or cement is not considered in the ratings.

The ratings are based on soil properties, site features, and observed performance of the soils. The thickness of suitable material is a major consideration. The ease of excavation is affected by large stones, a high water table, and slope. How well the soil performs in place after it has been compacted and drained is determined by its strength (as inferred from the engineering classification of the soil) and shrink-swell potential.

Soils rated *good* contain significant amounts of sand or gravel, or both. They have at least 150 centimeters of suitable material, low shrink-swell potential, few cobbles and stones, and slopes of 15 percent or less. Depth to the water table is more than 90 centimeters. Soils rated *fair* are more than 35 percent silt- and clay-sized particles and have a plasticity index of less than 10. They have moderate shrink-swell potential, slopes of 15 to 25 percent, or many stones. Depth to the water table is 30 to 90 centimeters. Soils rated *poor* have a plasticity index of more than 10, a high shrink-swell potential, many stones, or slopes of more than 25 percent. They are wet, and the depth to the water table is less than 30 centimeters. They may have layers of suitable material, but the material is less than 90 centimeters thick.

Sand and gravel are natural aggregates suitable for commercial use with a minimum of processing. Sand and gravel are used in many kinds of construction. Specifications for each use vary widely. In table 9, only the probability of finding material in suitable quantity is evaluated. The suitability of the material for specific purposes is not evaluated, nor are factors that affect excavation of the material.

The properties used to evaluate the soil as a source of sand or gravel are gradation of grain sizes (as indicated by the engineering classification of the soil), the thickness of suitable material, and the content of rock fragments. Kinds of rock, acidity, and stratification are given in the taxonomic unit descriptions. Gradation of grain sizes is given in the table on engineering index properties.

A soil rated as a *probable* source has a layer of clean sand or gravel or a layer of sand or gravel that is as much as 12 percent silty fines. This material must be at least 90 centimeters thick and less than 50 percent, by weight, large stones. All other soils are rated as an *improbable* source. Coarse fragments of soft bedrock, such as shale and siltstone, are not considered to be sand and gravel.

Topsoil is used to cover an area so that vegetation can be established and maintained. The upper 100 centimeters of a soil is evaluated for use as topsoil. Also evaluated is the reclamation potential of the borrow area.

Plant growth is affected by toxic material and by such properties as soil reaction, available water capacity, and fertility. The ease of excavating, loading, and spreading is affected by rock fragments, slope, a water table, soil texture, and thickness of suitable material. Reclamation of the borrow area is affected by slope, a water table, rock fragments, bedrock, and toxic material.

Soils rated *good* have friable loamy material to a depth of at least 100 centimeters. They are free of stones and cobbles, have little or no gravel, and have slopes of less than 8 percent. They are low in content of soluble salts, are naturally fertile or respond well to fertilizer, and are not so wet that excavation is difficult.

Soils rated *fair* are sandy soils, loamy soils that have a relatively high content of clay, soils that have only 50 to 100 centimeters of suitable material, soils that have an appreciable amount of gravel, stones, or soluble salts, or soils that have slopes of 8 to 15 percent. The soils are not so wet that excavation is difficult.

Soils rated *poor* are very sandy or clayey, have less than 50 centimeters of suitable material, have a large amount of gravel, stones, or soluble salts, have slopes of more than 15 percent, or have a seasonal water table at or near the surface.

The surface layer of most soils generally is preferred for topsoil because of its organic matter content. Organic matter greatly increases the absorption and retention of moisture and nutrients for plant growth.

Water Management

Table 10 gives information on the soil properties and site features that affect water management. The degree and kind of soil limitations are given for pond reservoir areas; embankments, dikes, and levees; and aquifer-fed ponds. The limitations are considered *slight* if soil properties and site features generally are favorable for the indicated use and limitations are minor and are easily overcome; *moderate* if soil properties or site features are not favorable for the indicated use and special planning, design, or maintenance is needed to overcome or minimize the limitations; and *severe* if soil properties or

site features are so unfavorable or so difficult to overcome that special design, significant increase in construction costs, and possibly increased maintenance are required.

This table also gives for each soil the restrictive features that affect drainage, terraces and diversions, and grassed waterways.

Pond reservoir areas hold water behind a dam or embankment. Soils best suited to this use have low seepage potential in the upper 150 centimeters. The seepage potential is determined by the permeability of the soil and the depth to fractured bedrock or other permeable material. Excessive slope can affect the storage capacity of the reservoir area.

Embankments, dikes, and levees are raised structures of soil material, generally less than 6 meters high, constructed to impound water or to protect land against overflow. In this table, the soils are rated as a source of material for embankment fill. The ratings apply to the soil material below the surface layer to a depth of about 150 centimeters. It is assumed that soil layers will be uniformly mixed and compacted during construction.

The ratings do not indicate the ability of the natural soil to support an embankment. Soil properties to a depth even more than the height of the embankment can affect performance and safety of the embankment. Generally, deeper onsite investigation is needed to determine these properties.

Soil material in embankments must be resistant to seepage, piping, and erosion and have favorable compaction characteristics. Unfavorable features include less than 150 centimeters of suitable material and a high content of stones or boulders, organic matter, or salts or sodium. A high water table affects the amount of usable material. It also affects trafficability.

Drainage is the removal of excess surface and subsurface water from the soil. How easily and effectively the soil is drained depends on the depth to bedrock, to a cemented pan, or to other layers that affect the rate of water movement; permeability; depth to a high water table or depth of standing water if the soil is subject to ponding; slope; susceptibility to flooding; subsidence of organic layers; and potential frost action. Excavating and grading and the stability of ditchbanks are affected by depth to bedrock or to a cemented pan, large stones, slope, and the hazard of cutbanks caving. The productivity of the soil after drainage is adversely affected by extreme acidity or by toxic substances in the root zone, such as salts, sodium, or sulfur. Availability of drainage outlets is not considered in the ratings.

Terraces and diversions are embankments or a combination of channels and ridges constructed across a slope to reduce erosion and conserve moisture by intercepting runoff. Slope, wetness, large stones, and depth to bedrock or to a cemented pan affect the construction of terraces and diversions. A restricted rooting depth, a severe hazard of wind or water erosion, an excessively coarse texture, and restricted permeability adversely affect maintenance.

Grassed waterways are natural or constructed channels, generally broad and shallow, that conduct surface water to outlets at a nonerosive velocity. Large stones, wetness, slope, and depth to bedrock or to a cemented pan affect the construction of grassed waterways. A hazard of wind erosion, low available water capacity, restricted rooting depth, toxic substances such as salts or sodium, and restricted permeability adversely affect the growth and maintenance of the grass after construction.

Soil Properties

Data relating to soil properties are collected during the course of the soil survey. The data and the estimates of soil and water features listed in tables are explained on the following pages.

Soil properties are determined by field examination of the soils and by laboratory index testing of some benchmark soils. Established standard procedures are followed. During the survey, many shallow borings are made and examined to identify and classify the soils and to delineate them on the soil maps. Samples are taken from some typical profiles and tested in the laboratory to determine grain-size distribution, plasticity, and compaction characteristics.

Estimates of soil properties are based on field examinations, on laboratory tests of samples from the survey area, and on laboratory tests of samples of similar soils in nearby areas. Tests verify field observations, verify properties that cannot be estimated accurately by field observation, and help to characterize key soils.

The estimates of soil properties shown in the tables include the range of grain-size distribution and Atterberg limits, the engineering classifications, and the physical and chemical properties of the major layers of each soil. Pertinent soil and water features also are given.

Engineering Index Properties

Table 11 gives estimates of the engineering classification and of the range of index properties for the major layers of each soil in the survey area. Most soils have layers of contrasting properties within the upper 150 centimeters.

Depth to the upper and lower boundaries of each layer is indicated. The range in depth and information on other properties of each layer are given for each soil series under "Soil Series and Their Morphology."

Texture is given in the standard terms used by the U.S. Department of Agriculture. These terms are defined according to percentages of sand, silt, and clay in the fraction of the soil that is less than 2 millimeters in diameter. "Loam," for example, is soil that is 7 to 27 percent clay, 28 to 50 percent silt, and less than 52 percent sand. If the content of particles coarser than sand is as much as 15 percent, an appropriate modifier is added; for example, "gravelly." Textural terms are defined in the Glossary.

Classification of the soils is determined according to the system adopted by the American Association of State Highway and Transportation Officials (*1*) and the Unified soil classification system (*2*).

The Unified system classifies soils according to properties that affect their use as construction material. Soils are classified according to grain-size distribution of the fraction less than 8 centimeters in diameter and according to plasticity index, liquid limit, and organic matter content. Sandy and gravelly soils are identified as GW, GP, GM, GC, SW, SP, SM, and SC; silty and clayey soils as ML, CL, OL, MH, CH, and OH; and highly organic soils as PT. Soils exhibiting engineering properties of two groups can have a dual classification; for example, SP-SM.

The AASHTO system classifies soils according to those properties that affect roadway construction and maintenance. In this system, the fraction of a mineral soil that is less than 8 centimeters in diameter is classified in one of seven groups from A-1 through A-7 on the basis of grain-size distribution, liquid limit, and plasticity index. Soils in group A-1 are coarse grained and low in content of fines (silt and clay). At the other extreme, soils in group A-7 are fine grained. Highly organic soils are classified in group A-8 on the basis of visual inspection.

Rock fragments larger than 8 centimeters in diameter are indicated as a percentage of the total soil on a dry-weight basis. The percentages are estimates determined mainly by converting volume percentage in the field to weight percentage.

Percentage (of soil particles) passing designated sieves is the percentage of the soil fraction less than 8 centimeters in diameter based on an ovendry weight. The sieves, numbers 4, 10, 40, and 200 (USA Standard Series), have openings of 4.76, 2.00, 0.420, and 0.074 millimeters, respectively. Estimates are based on laboratory tests of soils sampled in the survey area and in nearby areas and on estimates made in the field.

Liquid limit and *plasticity index* (Atterberg limits) indicate the plasticity characteristics of a soil. The estimates are based on test data from the survey area or from nearby areas and on field examination.

The estimates of grain-size distribution, liquid limit, and plasticity index are rounded to the nearest 5 percent. Thus, if the ranges of gradation and Atterberg limits extend a marginal amount (1 or 2 percentage points)

across classification boundaries, the classification in the marginal zone is omitted in the table.

Physical and Chemical Properties

Table 12 shows estimates of some characteristics and features that affect soil behavior. These estimates are given for the major layers of each soil in the survey area. The estimates are based on field observations and on test data for these and similar soils.

Depth to the upper and lower boundaries of each layer is indicated. The range in depth and information on other properties of each layer are given for each soil series under "Soil Series and Their Morphology."

Clay as a soil separate consists of mineral soil particles that are less than 0.002 millimeter in diameter. In this table, the estimated clay content of each major soil layer is given as a percentage, by weight, of the soil material that is less than 2 millimeters in diameter.

The amount and kind of clay greatly affect the fertility and physical condition of the soil. They determine the ability of the soil to adsorb cations and to retain moisture. They influence shrink-swell potential, permeability, plasticity, the ease of soil dispersion, and other soil properties. The amount and kind of clay in a soil also affect tillage and earth-moving operations.

Moist bulk density is the weight of soil (ovendry) per unit volume. Volume is measured when the soil is at field moisture capacity, that is, the moisture content at 1/3 bar moisture tension. Weight is determined after drying the soil at 105 degrees C. In this table, the estimated moist bulk density of each major soil horizon is expressed in grams per cubic centimeter of soil material that is less than 2 millimeters in diameter. Bulk density data are used to compute shrink-swell potential, available water capacity, total pore space, and other soil properties. The moist bulk density of a soil indicates the pore space available for water and roots. A bulk density of more than 1.6 can restrict water storage and root penetration. Moist bulk density is influenced by texture, kind of clay, content of organic matter, and soil structure.

Permeability refers to the ability of a soil to transmit water or air. The estimates indicate the rate of downward movement of water when the soil is saturated. They are based on soil characteristics observed in the field, particularly structure, porosity, and texture. Permeability is considered in the design of soil drainage systems, septic tank absorption fields, and construction where the rate of water movement under saturated conditions affects behavior.

Available water capacity refers to the quantity of water that the soil is capable of storing for use by plants. The capacity for water storage is given in centimeters of water per centimeters of soil for each major soil layer. The capacity varies, depending on soil properties that affect the retention of water and the depth of the root zone. The most important properties are the content of organic matter, soil texture, bulk density, and soil structure. Available water capacity is an important factor in the choice of plants or crops to be grown and in the design and management of irrigation systems. Available water capacity is not an estimate of the quantity of water actually available to plants at any given time.

Soil reaction is a measure of acidity or alkalinity and is expressed as a range in pH values. The range in pH of each major horizon is based on many field tests. For many soils, values have been verified by laboratory analyses. Soil reaction is important in selecting crops and other plants, in evaluating soil amendments for fertility and stabilization, and in determining the risk of corrosion.

Salinity is a measure of soluble salts in the soil at saturation. It is expressed as the electrical conductivity of the saturation extract, in millimhos per centimeter at 25 degrees C. Estimates are based on field and laboratory measurements at representative sites of nonirrigated soils. The salinity of irrigated soils is affected by the quality of the irrigation water and by the frequency of water application. Hence, the salinity of soils in individual fields can differ greatly from the value given in the table. Salinity affects the suitability of a soil for crop production, the stability of the soil if used as construction material, and the potential of the soil to corrode metal and concrete.

Shrink-swell potential is the potential for volume change in a soil with a loss or gain in moisture. Volume change occurs mainly because of the interaction of clay minerals with water and varies with the amount and type of clay minerals in the soil. The size of the load on the soil and the magnitude of the change in soil moisture content influence the amount of swelling of soils in place. Laboratory measurements of swelling of undisturbed clods were made for many soils. For others, swelling was estimated on the basis of the kind and amount of clay minerals in the soil and on measurements of similar soils.

If the shrink-swell potential is rated moderate to very high, shrinking and swelling can cause damage to buildings, roads, and other structures. Special design is often needed.

Shrink-swell potential classes are based on the change in length of an unconfined clod as moisture content is increased from air-dry to field capacity. The change is based on the soil fraction less than 2 millimeters in diameter. The classes are *low*, a change of less than 3 percent; *moderate*, 3 to 6 percent; and *high*, more than 6 percent. *Very high*, more than 9 percent, is sometimes used.

Erosion factor K indicates the susceptibility of a soil to sheet and rill erosion. Factor K is one of six factors used in the Universal Soil Loss Equation (USLE) to predict the average rate of soil loss by sheet and rill erosion in tons per acre per year. The estimates are based primarily on percentage of silt, very fine sand, sand, and organic

matter (as much as 4 percent) and on soil structure and permeability. The estimates are modified by the presence of rock fragments. Values of K range from 0.02 to 0.69. The higher the value the more susceptible the soil is to sheet and rill erosion.

Erosion factor T is an estimate of the maximum average rate of soil erosion by wind or water that can occur without affecting crop productivity over a sustained period. The rate is in tons per acre per year.

Organic matter is the plant and animal residue in the soil at various stages of decomposition.

In table 12, the estimated content of organic matter is expressed as a percentage, by weight, of the soil material that is less than 2 millimeters in diameter.

The content of organic matter of a soil can be maintained or increased by returning crop residue to the soil. Organic matter affects the available water capacity, infiltration rate, and tilth. It is a source of nitrogen and other nutrients for crops.

Soil and Water Features

Table 13 gives estimates of various soil and water features. The estimates are used in land use planning that involves engineering considerations.

Hydrologic soil groups are used to estimate runoff from precipitation. Soils not protected by vegetation are assigned to one of four groups. They are grouped according to the intake of water when the soils are thoroughly wet and receive precipitation from long-duration storms.

The four hydrologic soil groups are:

Group A. Soils having a high infiltration rate (low runoff potential) when thoroughly wet. These consist mainly of deep, well drained to excessively drained sand or gravelly sand. These soils have a high rate of water transmission.

Group B. Soils having a moderate infiltration rate when thoroughly wet. These consist chiefly of moderately deep or deep, moderately well drained or well drained soils that have moderately fine texture to moderately coarse texture. These soils have a moderate rate of water transmission.

Group C. Soils having a slow infiltration rate when thoroughly wet. These consist chiefly of soils having a layer that impedes the downward movement of water or soils of moderately fine texture or fine texture. These soils have a slow rate of water transmission.

Group D. Soils having a very slow infiltration rate (high runoff potential) when thoroughly wet. These consist chiefly of clay that has high shrink-swell potential, soils that have a permanent high water table, soils that have a claypan or clay layer at or near the surface, and soils that are shallow over nearly impervious material. These soils have a very slow rate of water transmission.

Flooding, the temporary covering of the soil surface by flowing water, is caused by overflow from streams, by runoff from adjacent slopes, or by inflow from high tides. Shallow water standing or flowing for short periods after rainfall or snowmelt is not considered to be flooding. Standing water in swamps and marshes or in closed depressional areas is considered to be ponding.

Table 13 gives the frequency and duration of flooding and the time of year when flooding is most likely to occur.

Frequency, duration, and probable period of flooding are estimated. Frequency is expressed as *none, rare, occasional, and frequent*. *None* means that flooding is not probable, *rare* that it is unlikely but is possible under unusual weather conditions (chance of flooding in any year is 0 to 5 percent), *occasional* that it occurs infrequently under normal weather conditions (chance of flooding in any year is 5 to 50 percent), and *frequent* that it occurs often under normal weather conditions (chance of flooding in any year is more than 50 percent).

Duration is expressed as *very brief* (less than 2 days), *brief* (2 to 7 days), *long* (7 days to 1 month), and *very long* (more than 1 month). The time of year that flooding is most likely to occur is expressed in months. November-May, for example, means that flooding can occur during the period November through May. About two-thirds to three-fourths of all flooding occurs during the stated period.

The information on flooding is based on evidence in the soil profile, namely thin strata of gravel, sand, silt, or clay deposited by floodwater; irregular decrease in organic matter content with increasing depth; and absence of distinctive horizons, which are characteristic of soils that are not subject to flooding.

Also considered are local information about the extent and level of flooding and the relation of each soil on the landscape to historic flood. Information on the extent of flooding based on soil data is less specific than that provided by detailed engineering surveys that delineate flood-prone areas at specific flood frequency levels.

High water table (seasonal) is the highest level of a saturated zone in the soil in most years. The depth to a seasonal high water table applies to undrained soils. The estimates are based mainly on the evidence of a saturated zone, namely grayish colors or mottles in the soil. Indicated in table K are the depth to the seasonal high water table; the kind of water table—that is, *perched, artesian,* or *apparent*; and the months of the year that the water table usually is highest. A water table that is seasonally high for less than 1 month is not indicated in the table.

An *apparent* water table is a thick zone of free water in the soil. It is indicated by the level at which water stands in an uncased borehole after adequate time is allowed for adjustment in the surrounding soil. An *artesian* water table is under hydrostatic head, generally below an impermeable layer. When this layer is penetrated, the water level rises in an uncased borehole. A *perched* water table is water standing above an

unsaturated zone. In places an upper, or perched, water table is separated from a lower water table by a dry zone.

The two numbers in the column "High water table" indicate the normal range in depth to a saturated zone. The first numeral in the range indicates the highest water level. A plus sign preceding the range in depth indicates that the water table is above the surface of the soil. "More than 180" indicates that the water table is below a depth of 180 centimeters or that the water table exists for less than a month.

Depth to bedrock is given if bedrock is within a depth of 150 centimeters. The depth is based on many soil borings and on observations during soil mapping. The rock is specified as either soft or hard. If the rock is soft or fractured, excavations can be made with trenching machines, backhoes, or small rippers. If the rock is hard or massive, blasting or special equipment generally is needed for excavation.

Risk of corrosion pertains to potential soil-induced electrochemical or chemical action that dissolves or weakens uncoated steel or concrete. The rate of corrosion of uncoated steel is related to such factors as soil moisture, particle-size distribution, acidity, and electrical conductivity of the soil. The rate of corrosion of concrete is based mainly on the sulfate and sodium content, texture, moisture content, and acidity of the soil. Special site examination and design may be needed if the combination of factors creates a severe corrosion environment. The steel in installations that intersect soil boundaries or soil layers is more susceptible to corrosion than steel in installations that are entirely within one kind of soil or within one soil layer.

For uncoated steel, the risk of corrosion, expressed as *low*, *moderate*, or *high*, is based on soil drainage class, total acidity, electrical resistivity near field capacity, and electrical conductivity of the saturation extract.

For concrete, the risk of corrosion is also expressed as *low*, *moderate*, or *high*. It is based on soil texture, acidity, and amount of sulfates in the saturation extract.

Classification of the Soils

The system of soil classification used by the National Cooperative Soil Survey has six categories (*21*). Beginning with the broadest, these categories are the order, suborder, great group, subgroup, family, and series. Classification is based on soil properties observed in the field or inferred from those observations or from laboratory measurements. Table 14 shows the classification of the soils in the survey area. The categories are defined in the following paragraphs.

ORDER. Ten soil orders are recognized. The differences among orders reflect the dominant soil-forming processes and the degree of soil formation. Each order is identified by a word ending in *sol*. An example is Alfisol.

SUBORDER. Each order is divided into suborders primarily on the basis of properties that influence soil genesis and are important to plant growth or properties that reflect the most important variables within the orders. The last syllable in the name of a suborder indicates the order. An example is Ustalf (*Ust*, meaning burnt and implying dryness, plus *alf*, from Alfisol).

GREAT GROUP. Each suborder is divided into great groups on the basis of close similarities in kind, arrangement, and degree of development of pedogenic horizons; soil moisture and temperature regimes; and base status. Each great group is identified by the name of a suborder and by a prefix that indicates a property of the soil. An example is Haplustalfs (*Hapl*, meaning simple, plus *ustalf*, the suborder of the Alfisols that are dry during part of the year).

SUBGROUP. Each great group has a typic subgroup. Other subgroups are intergrades or extragrades. The typic is the central concept of the great group; it is not necessarily the most extensive. Intergrades are transitions to other orders, suborders, or great groups. Extragrades have some properties that are not representative of the great group but do not indicate transitions to any other known kind of soil. Each subgroup is identified by one or more adjectives preceding the name of the great group. The adjective *Oxic* identifies the subgroup that typifies the great group. An example is Oxic Haplustalfs.

FAMILY. Families are established within a subgroup on the basis of physical and chemical properties and other characteristics that affect management. Mostly the properties are those of horizons below plow depth where there is much biological activity. Among the properties and characteristics considered are particle-size class, mineral content, temperature regime, thickness of the root zone, consistence, moisture equivalent, slope, and permanent cracks. A family name consists of the name of a subgroup preceded by terms that indicate soil properties. An example is very fine, kaolinitic, isohyperthermic Oxic Haplustalfs.

SERIES. The series consists of soils that have similar horizons in their profile. The horizons are similar in color, texture, structure, reaction, consistence, mineral and chemical composition, and arrangement in the profile. The texture of the surface layer or of the substratum can differ within a series.

Soil Series and Their Morphology

In this section, each soil series recognized in the survey area is described. The descriptions are arranged in alphabetic order.

Characteristics of the soils and the material in which they formed are identified for each series. A pedon, a small three-dimensional area of soil, that is typical of the series in the survey area is described. The detailed description of each soil horizon follows standards in the *Soil Survey Manual* (*20*). Many of the technical terms used in the descriptions are defined in *Soil Taxonomy* (*21*). Unless otherwise stated, colors in the descriptions are for moist soil. Following the pedon description is the range of important characteristics of the soils in the series.

The map units of each soil series are described in the section "Detailed Soil Map Units."

Agfayan Series

The Agfayan series consists of well drained, moderately slowly permeable soils that are very shallow and shallow to strongly weathered tuff. These soils are on volcanic uplands. They formed in residuum derived from marine-deposited tuff, tuff breccia, and tuffaceous sandstone. Slopes are 7 to 99 percent. The mean annual precipitation is about 229 centimeters, and the mean annual temperature is about 26 degrees C.

Taxonomic class: Clayey, montmorillonitic, isohyperthermic, shallow Udic Haplustolls.

Typical pedon: Agfayan clay, 15 to 30 percent slopes; on a 20-percent, convex slope in an area under a thick

stand of swordgrass (*Miscanthus floridulus*). Textures are apparent field textures. When described, the soil was dry throughout.

A1—0 to 3 centimeters; black (10YR 2/1) clay, black (10YR 2/1) dry; strong fine granular structure; hard, friable, very sticky and very plastic; many very fine and fine roots; many very fine and fine interstitial pores; cracks as much as 1.25 centimeters wide at the surface; slightly acid (pH 6.4); clear broken boundary. (0 to 5 centimeters thick).

A2—3 to 10 centimeters; black (10YR 2/1) clay, black (10YR 2/1) dry; moderate coarse subangular blocky structure parting to strong fine subangular blocky; very hard, very firm, very sticky and very plastic; many very fine and fine roots; few very fine tubular pores in peds and many fine interstitial pores; cracks as much as 1.25 centimeters wide; slightly acid (pH 6.4); clear smooth boundary. (7 to 15 centimeters thick)

A3—10 to 20 centimeters; black (10YR 2/1) clay, black (10YR 2/1) dry; moderate coarse subangular blocky structure parting to moderate fine subangular blocky; very hard, very firm, very sticky and very plastic; many very fine and fine roots; many very fine and fine interstitial pores and few fine tubular pores; 15 percent saprolitic pebbles that can easily be crushed to coarse sand and rubbed to sandy clay; cracks less than 1.25 centimeters wide; neutral (pH 6.7); clear wavy boundary. (5 to 15 centimeters thick)

A/C—20 to 36 centimeters; mixed black (10YR 2/1) and yellowish brown (10YR 5/4) clay, black (10YR 2/1) and very pale brown (10YR 7/3) dry; moderate fine subangular blocky structure; very hard, very firm, very sticky and very plastic; many very fine and fine roots; few thin clay films along fractures and on faces of pebbles; saprolitic pebbles can be crushed to coarse sand and rubbed to sandy clay; slightly acid (pH 6.5); clear broken boundary. (0 to 20 centimeters thick)

Cr—36 centimeters; yellowish brown (10YR 5/4) weathered andesitic tuffaceous sandstone, very pale brown (10YR 7/3) dry; can be dug with spade; occasional deep fractures that contain black and yellowish brown clay; many very fine roots; neutral (pH 6.9).

Type location: Guam; prominent south-facing roadcut along the east side of the road to Ija Experiment Station, about 0.4 kilometer north of main highway; lat. 13°15'10' N. and long. 144°43'10' E.

Range in characteristics: The soils are not continuously moist in all parts of the moisture control section for 90 to 120 cumulative days, primarily between February and May. The soils usually are moist from July through December. The soil temperature is 27 to 30 degrees C, and it varies less than 2 degrees between summer and winter. The mollic epipedon is 10 to 26 centimeters thick. Depth to paralithic contact is 10 to 38 centimeters. Content of clay above paralithic contact is 60 to 80 percent. Content of coarse fragments, mainly weathered pebbles, commonly is 10 to 20 percent but ranges from 2 to 30 percent. Unweathered pebbles and cobbles cover as much as 10 percent of the surface in steeper areas.

The A horizon has color of 10YR 2/1, 3/1, 3/2, or 3/3, of 2.5Y 3/2, or of 7.5YR 3/2. Structure is granular or subangular blocky. Reaction is slightly acid or neutral.

The Bw horizon is present in some pedons at a depth of 26 centimeters or less. It has color of dominantly 10YR 4/2, 4/3, 5/3, or 5/4 or of 2.5Y 5/3 or 6/3. Some faces of peds have color of 5YR 4/6 or 4/8. Texture and structure are similar to those of the A horizon. Reaction is slightly acid or neutral.

An A/C horizon is present in some pedons.

The C horizon is present in some pedons at a depth of more than 18 centimeters. It has color of 10YR 5/4, 5/6, or 6/6, of 2.5YR 5/2, 6/2, or 7/2, or of 5Y 4/3.

The Cr horizon has hue of 10YR, 2.5Y, or 5Y and commonly has value of more than 4. Some pedons have calcareous strata.

In some pedons an R horizon is below a depth of 102 centimeters.

Akina Series

The Akina series consists of very deep, well drained, moderately slowly permeable soils on volcanic uplands. These soils formed in residuum derived from tuff and tuff breccia. Slopes are 0 to 99 percent. The mean annual precipitation is about 229 centimeters, and the mean annual temperature is about 26 degrees C.

Taxonomic class: Very fine, kaolinitic, isohyperthermic Oxic Haplustalfs.

Typical pedon: Akina silty clay, 3 to 7 percent slopes; on a 4-percent, east-facing slope in an area under savannah vegetation dominated by swordgrass (*Miscanthus floridulus*). Textures are apparent field textures.

A1—0 to 3 centimeters; dark reddish brown (5YR 3/3) silty clay, dark reddish brown (5YR 3/4) dry; moderate fine granular structure; 0.5-centimeter-thick crust on surface; slightly hard, very friable, slightly sticky and slightly plastic; many very fine roots; many very fine interstitial pores; very strongly acid (pH 5.0); abrupt smooth boundary. (1 to 5 centimeters thick)

A2—3 to 10 centimeters; dark reddish brown (2.5YR 3/4) silty clay; moderate medium subangular blocky structure; hard, firm, sticky and plastic; many very fine and fine roots; many very fine interstitial and tubular pores; very strongly acid (pH 5.0); gradual smooth boundary. (5 to 15 centimeters thick)

Bt1—10 to 20 centimeters; dark red (2.5YR 3/6) clay, red (2.5YR 4/6) dry; moderate coarse prismatic structure parting to moderate medium angular blocky; hard, firm, sticky and plastic; many very fine exped roots; common very fine tubular pores and few very fine interstitial pores; many thick dark reddish brown (2.5YR 3/4) clay films on prism faces and common thin clay films on blocky faces of peds and lining pores; common pressure faces on peds; very strongly acid (pH 4.9); gradual wavy boundary. (10 to 30 centimeters thick)

Bt2—20 to 41 centimeters; dark red (2.5YR 3/6) clay, red (2.5YR 4/6) dry; moderate coarse prismatic structure parting to moderate medium subangular blocky; hard, firm, sticky and plastic; common very fine exped roots; common very fine tubular pores and few very fine interstitial pores; many thick dark reddish brown (2.5YR 3/4) clay films on prism faces and common thin clay films on blocky faces of peds and lining pores; common pressure faces on peds; very strongly acid (pH 5.0); diffuse smooth boundary. (10 to 41 centimeters thick)

Bt3—41 to 61 centimeters; dark red (2.5YR 3/6) clay, red (2.5YR 4/6) dry; weak very fine subangular blocky structure; hard, firm, sticky and plastic; common very fine exped roots; few very fine interstitial and tubular pores; few moderately thick and many thin clay films on faces of peds and lining pores; common pressure faces on peds; about 10 percent fine pebble-sized saprolite fragments that are pale yellow (2.5Y 7/4) with reddish yellow (7.5YR 6/8) stains; strongly acid (pH 5.1); gradual wavy boundary. (10 to 30 centimeters thick)

C1—61 to 109 centimeters; about 50 percent dark red (10R 3/6) and 50 percent white (2.5Y 8/2) strongly weathered tuffaceous saprolite with reticulate joints, bedding planes, and rock structure; crushes to clay on wetting and rubbing; few very fine roots; few very fine tubular and interstitial pores; thin clay films lining pores; few pressure faces along bedding planes and joints; strongly acid (pH 5.3); diffuse smooth boundary. (0 to 61 centimeters thick)

C2—109 to 152 centimeters; strongly weathered tuffaceous saprolite that crushes to silty clay; about 50 percent of saprolite is dark red (10R 3/6) coarse blocks and 50 percent is white (2.5Y 8/2) and occurs in a reticulate pattern along joints and bedding planes; rock structure; few very fine roots along bedding planes and joints; many moderately thick yellowish red (5YR 5/8) clay films along faces of planes; the dark red material is firmer and contains fine saprolitic flecks; very strongly acid (pH 5.0).

Type location: Guam; Ija Experiment Station, about 49 meters northeast of the end of the paved road, adjacent to an erosional bank that fringes a plateau; lat. 13°16'27' N. and long. 144°42'50' E.

Range in characteristics: These soils are not continuously moist in all parts of the moisture control section for 90 to 120 cumulative days, primarily between February and May. The moisture control section usually is moist from July through December. The soil temperature is 27 to 30 degrees C, and it varies less than 2 degrees between summer and winter. Depth to saprolite is 51 to 102 centimeters. Content of clay in the argillic horizon is 60 to 80 percent.

The A horizon has color of 2.5YR 3/2 or 3/4, of 5YR 3/2, 3/3, or 3/4, of 7.5YR 3/1 or 3/2, or of 10YR 3/3. Texture is silty clay or clay. Structure is granular or subangular blocky. Reaction is very strongly acid or strongly acid. From 0 to 10 percent of the surface is covered with pebbles.

The B horizon has color of 10R 3/4 or 3/6 or of 2.5YR 3/4 or 3/6. Structure is prismatic, angular blocky, or subangular blocky. Reaction is very strongly acid to medium acid. Sand- and pebble-sized saprolitic flecks are common in the lower part of the horizon. These commonly have value and chroma of more than 3 to as much as 8.

The matrix of the C horizon has color of dominantly 2.5YR 3/6, 4/6, or 4/8 or of 10R 3/6. The horizon also has hue of 5YR, 7.5YR, or 10YR, value of more than 3, and variable chroma. These subordinate colors commonly are present as discrete sand- and pebble-sized saprolitic flecks and bands. Texture is clay loam, silty clay, or clay when rubbed. The horizon is massive or has rock structure.

Atate Series

The Atate series consists of very deep, moderately permeable, well drained soils on volcanic uplands. These soils formed in residuum derived from tuff and tuff breccia. Slopes are 0 to 60 percent. The mean annual precipitation is about 229 centimeters, and the mean annual temperature is about 26 degrees C.

Taxonomic class: Very-fine, oxidic, isohyperthermic Oxic Haplustalfs.

Typical pedon: Atate silty clay in an area of Akina-Atate silty clays, 0 to 7 percent slopes; on a nearly level upland bench in an area of a young forestry plantation with herbaceous cover. Textures are apparent field textures.

Ap1—0 to 3 centimeters; dark reddish brown (5YR 3/3) silty clay; moderate very fine granular structure; hard, friable, sticky and plastic; many very fine roots, common fine roots, and few medium and coarse roots; many very fine and fine interstitial pores; strongly acid (pH 5.5); clear smooth boundary. (0 to 5 centimeters thick)

Ap2—3 to 13 centimeters; dark reddish brown (5YR 3/3) silty clay; moderate very fine subangular blocky structure; hard, friable, sticky and plastic; many very fine roots, common fine roots, and few medium and coarse roots; many very fine and fine tubular and interstitial pores; strongly acid (pH 5.5.); clear smooth boundary. (10 to 25 centimeters thick)

A—13 to 30 centimeters; dark reddish brown (5YR 3/4) clay; weak medium subangular blocky structure parting to moderate very fine subangular blocky; friable, sticky and plastic; common very fine roots and few fine roots; many very fine and few fine tubular pores; slightly acid (pH 6.2); gradual smooth boundary. (0 to 20 centimeters thick)

Bt1—30 to 56 centimeters; yellowish red (5YR 4/6) clay; moderate very fine subangular blocky structure; friable, sticky and plastic; common very fine roots and few fine roots; many very fine and few fine tubular pores; pressure faces on peds; few thin clay films on faces of peds and lining pores; medium acid (pH 5.8); gradual smooth boundary. (20 to 61 centimeters thick)

Bt2—56 to 91 centimeters; dark red (2.5YR 3/6) clay; moderate very fine subangular blocky structure; friable, sticky and plastic; common very fine roots and few fine roots; many very fine and few fine tubular pores; pressure faces on peds; few thin clay films on faces of peds and lining pores; medium acid (pH 5.9); diffuse smooth boundary. (20 to 51 centimeters thick)

Bt3—91 to 109 centimeters; dark red (2.5YR 3/6) clay; moderate very fine subangular blocky structure; friable, sticky and plastic; common very fine roots; many very fine and few fine tubular pores; pressure faces on peds; few thin clay films on vertical faces of peds and lining pores; less than 1 percent saprolitic flecks, irregularly distributed; medium acid (pH 6.0); diffuse smooth boundary. (0 to 30 centimeters thick)

B/C—109 to 140 centimeters; dark red (2.5YR 3/6) clay; weak very fine subangular blocky structure; friable, sticky and plastic; few very fine roots; many very fine and few fine tubular pores; few thin clay films on vertical faces of peds and lining pores; about 5 percent saprolitic sand-sized flecks; medium acid (pH 6.0); abrupt smooth boundary. (10 to 41 centimeters thick)

C—140 to 165 centimeters; clay that is about 30 percent dark red (10R 3/6), 30 percent weak red (10R 4/4), 30 percent red (10R 4/6), and 10 percent yellowish red (5YR 4/6) and dark brown (7.5YR 4/6) patches 3 to 5 centimeters in diameter; weak very fine subangular blocky structure; very friable, sticky and plastic; few very fine roots; common very fine tubular pores; many sand-sized saprolitic flecks; few black irregular manganese stains; medium acid (pH 5.7).

Type location: Guam; Cotal Conservation Area, along road to Tarzan Falls trailhead, about 200 meters from highway on east side of road; lat. 13°23'25' N. and long. 144°43'10' E.

Range in characteristics: These soils are not continuously moist in all parts of the control section for 90 to 120 cumulative days, primarily between February and May. The soils usually are moist from July through December. The soil temperature is 27 to 30 degrees C, and it varies less than 2 degrees between summer and winter. Depth to saprolite is 102 to 152 centimeters or more. Content of clay in the argillic horizon is 60 to 90 percent.

The A horizon has color of 2.5YR 3/4 or 4/4, of 5YR 3/3 or 3/4, or of 7.5YR 3/2. Texture is clay loam, silty clay loam, silty clay, or clay. Structure is granular or subangular blocky. Reaction is very strongly acid to slightly acid. Content of pebbles is 0 to 2 percent.

The B horizon has color of dominantly 2.5YR 4/6 or 3/6 or 5YR 3/6 or 4/6, but it ranges to 10R 4/6 or 4/8, 5YR 4/8 or 5/8, or 7.5YR 5/8. Structure is prismatic, angular blocky, or subangular blocky. Reaction is very strongly acid to medium acid.

The C horizon has hue of dominantly 10R or 2.5YR, but it ranges from 5YR to 10YR. Texture is clay or silty clay. Reaction is very strongly acid to medium acid.

Chacha Series

The Chacha series consists of very deep, somewhat poorly drained, slowly permeable soils in concave basins on limestone plateaus. These soils formed in alluvial sediment and volcanic saprolite overlying limestone. Slopes are 0 to 7 percent. The mean annual precipitation is about 229 centimeters, and the mean annual temperature is about 26 degrees C.

Taxonomic class: Very-fine, kaolinitic, isohyperthermic Oxic Haplustalfs.

Typical pedon: Chacha clay, 0 to 5 percent slopes; in a level area adjacent to a crop of yardlong beans. Textures are apparent field textures.

Ap1—0 to 10 centimeters; dark brown (10YR 3/3) clay; moderate medium subangular blocky structure parting to strong fine subangular blocky; hard, friable, sticky and plastic; many very fine roots; common very fine and fine tubular pores and few fine interstitial pores; common fine rounded black manganese concretions; medium acid (pH 6.0); clear wavy boundary. (5 to 13 centimeters thick)

Ap2—10 to 20 centimeters; mixed dark brown (10YR 3/3) and dark yellowish brown (10YR 3/4) clay; moderate very fine subangular blocky structure; friable, sticky and plastic; many very fine roots; common very fine and fine tubular pores and few fine interstitial pores; common fine subrounded black manganese concretions; medium acid (pH

6.0); clear wavy boundary. (10 to 25 centimeters thick)

Bt1—20 to 58 centimeters; strong brown (7.5YR 5/6) clay with few medium faint yellowish red (5YR 5/6) patches; moderate very fine and fine subangular blocky structure; firm, very sticky and very plastic; few very fine roots; common very fine and few fine and medium tubular pores and common very fine interstitial pores; common thin clay films on faces of peds and lining pores; pressure faces on peds; common fine subrounded black manganese concretions and nodules; neutral (pH 6.8); gradual wavy boundary. (30 to 79 centimeters thick)

Bt2—58 to 84 centimeters; variegated, about 50 percent strong brown (7.5YR 5/6), 30 percent yellowish red (5YR 4/6), and 20 percent red (2.5YR 4/8) clay; about 20 percent 0.3- to 1.25-centimeter-thick irregularly shaped black manganese nodules; moderate medium subangular blocky structure; firm, very sticky and very plastic; few very fine roots; common very fine and few fine tubular pores and few very fine interstitial pores; common thin clay films on faces of peds and lining pores; pressure faces on peds; some pores stained by dark brown decomposing roots; mildly alkaline (pH 7.5); diffuse smooth boundary. (20 to 61 centimeters thick)

Bt3—84 to 109 centimeters; variegated, about 50 percent strong brown (7.5YR 5/6) and 50 percent red (2.5YR 4/8) clay; about 40 percent 0.3- to 3.75-centimeter-thick irregularly shaped black manganese nodules and few 1.25-centimeter-thick prominent elongated seams of very pale brown (10YR 7/4) and red (2.5YR 4/5) soil material; soil material is slightly brittle; moderate fine subangular blocky structure; friable, very sticky and very plastic; few very fine roots; common very fine and few fine tubular pores and few very fine interstitial pores; common thin pressure faces on faces of peds; few thin clay films on faces of peds and lining pores; some pores, mainly in seams, are stained with decomposing roots; mildly alkaline (pH 7.8); diffuse smooth boundary. (20 to 30 centimeters thick)

C—109 to 160 centimeters; 40 percent strong brown (7.5YR 5/6), 40 percent red (2.5YR 4/8), and 20 percent white (10YR 8/1) strongly weathered saprolite that crushes to clay; moderate fine subangular blocky structure; friable, very sticky and very plastic; few very fine roots; common very fine and few fine tubular pores and few very fine interstitial pores; pressure faces on peds; white soil material in long seams about 1.25 centimeters wide and tilted at approximately 45 degrees; red soil material is slightly brittle; slickensides along the white seams; common dark brown (7.5YR 3/2) stains in pores in the white seams; mildly alkaline (pH 7.7).

Type location: Guam; about 100 meters west of Talofofo Village along a farm road, about 5 meters north of the road; lat. 13°21'25' N. and long. 144°45'0' E.

Range in characteristics: These soils are not continuously moist in all parts of the moisture control section for 90 to 120 cumulative days, primarily between February and May. The moisture control section usually is moist from July through December. Unless the soils are drained, a water table is present between depths of 51 to 91 centimeters during July through December. The soil temperature is 27 to 30 degrees C, and it varies less than 2 degrees between summer and winter. Depth to bedrock is 150 centimeters or more. Depth to saprolite is 102 to 127 centimeters. Content of clay in the argillic horizon is 60 to 90 percent.

The A horizon has color of 7.5YR 3/2 or of 10YR 3/2, 3/3, or 3/4. Texture is silty clay or clay. In undisturbed areas a thin clay loam or silty clay loam A1 horizon is present. Reaction is medium acid to mildly alkaline. The horizon is 0 to 5 percent pebbles. In some pedons the A horizon extends into the B horizon along pores, cracks, and wormholes.

The B horizon has color of dominantly 7.5YR 4/4, 5/6, or 5/8, and it has irregular patches that increase with increasing depth and have color of 2.5YR 3/6, 4/3, 4/6, 4/8, 5/6, or 5/8 or of 5YR 5/6, 4/4, 4/6, or 4/8. Structure is angular or subangular blocky. Reaction is strongly acid to mildly alkaline. Manganese concretions, nodules, and stains are present in all pedons, but content ranges from none to about 40 percent, by volume, in individual subhorizons.

About 50 percent of the C horizon has hue of 7.5YR, and 50 percent has hue of 2.5YR or 5YR. Value and chroma are similar to those of the B horizon. Thin (less than 1.25 centimeters thick) seams or joints make up 5 to 30 percent of the horizon, and they have color of 10YR 5/6, 6/6, 7/2, 7/4, 7/6, or 8/1 or of 2.5YR 7/2 or 7/4. Manganese concretions, nodules, and stains are common. Reaction is strongly acid to mildly alkaline.

Chacha Variant

The Chacha Variant consists of very deep, poorly drained, slowly permeable soils in basins on limestone plateaus. These soils formed in alluvial sediment overlying limestone. Slopes are 0 to 3 percent. The mean annual precipitation is about 229 centimeters, and the mean annual temperature is about 26 degrees C.

Taxonomic class: Very-fine, kaolinitic, isohyperthermic Typic Tropaqualfs.

Typical pedon: Chacha Variant clay, 0 to 3 percent slopes. Textures are apparent field textures.

A1—0 to 15 centimeters; very dark grayish brown (10YR 3/2) clay; surface is very dark gray (10YR 3/1); strong fine subangular blocky structure; very hard, very firm, very sticky and very plastic; common fine

and very fine roots; neutral (pH 6.7); gradual smooth boundary. (5 to 18 centimeters thick)

A2—15 to 28 centimeters; dark grayish brown (2.5Y 4/2) clay; strong very fine subangular blocky structure; hard, firm, very sticky and very plastic; few fine roots and common very fine roots; few fine round black concretions; neutral (pH 6.8); clear wavy boundary. (10 to 30 centimeters thick)

B/A—28 to 70 centimeters; dark brown (10YR 3/3, 4/3) and dark yellowish brown (10YR 4/4) clay; strong very fine subangular blocky structure; firm, very sticky and very plastic; few fine and very fine roots; common large smooth pressure faces; many coarse black soft concretions and few fine black round concretions; few worm casts of A2 material; mildly alkaline (pH 7.5); diffuse smooth boundary. (10 to 48 centimeters thick)

Bt1—70 to 110 centimeters; strong brown (7.5YR 5/6) clay; common fine light gray (5Y 7/1, 7/2) and pale yellow (5Y 7/3) reticulate mottles along pores and faces of peds and few fine brown (7.5YR 4/4) patches, commonly associated with few fine black rounded concretions; strong very fine subangular blocky structure; firm, very sticky and very plastic; few fine and very fine roots; shiny pressure faces on peds; mildly alkaline (pH 7.6); diffuse smooth boundary. (10 to 48 centimeters thick)

Bt2—110 to 150 centimeters; strong brown (7.5YR 5/6) clay; few fine olive gray (5Y 5/2) and light gray (5Y 7/1) reticulate mottles and common fine light olive brown (2.5Y 5/4) reticulate mottles along pores and faces of peds; few fine and medium brown (7.5YR 4/4) patches; strong very fine subangular blocky structure; firm, very sticky and very plastic; few very fine roots; few very fine round black concretions; mildly alkaline (pH 7.5).

Type location: Guam; about 750 meters west of Talofofo Village and then about 120 meters northeast of Route 4A; lat. 13°21'15' N. and long. 144°44'45' E.

Range in characteristics: These soils usually are dry in the moisture control section for 90 to 120 cumulative days, primarily between February and May. The moisture control section usually is moist or wet from July through December. Ponding is common for extended periods between July and November. The soil temperature is 27 to 30 degrees C, and it varies less than 2 degrees between summer and winter. Depth to mottles that have low chroma is 30 to 75 centimeters. Depth to bedrock is 150 to 200 centimeters or more. Content of clay in the argillic horizon is 60 to 90 percent. In some areas the soils have hummocks 12 centimeters high and 30 centimeters across that commonly are joined into chains. Cracks as much as 5 centimeters wide are present in the upper part of the soil during the dry season, but they are less than 1 centimeter wide at a depth of 40 centimeters.

The upper part of the A horizon has color of 10YR 2/1, 3/1, 3/2, or 3/3 or of 2.5Y 3/2, and the lower part has color of 10YR 3/3 or 4/2 or of 2.5Y 4/2. Reaction is slightly acid or neutral.

The B horizon has color of 7.5YR 5/6 or 5/8 or of 10YR 5/6, 5/8, 6/6, or 6/8. Mottles have color of 10YR 6/2, 6/3, 7/2, or 7/3, of 2.5Y 5/3, of 5Y 5/2, 6/2, 7/1, 7/2, or 7/3, or of 5BG, 5B, 5GY, or 5G 7/1. The horizon is 0 to 5 percent pebbles below a depth of 100 centimeters. Reaction is strongly acid to mildly alkaline.

Guam Series

The Guam series consists of well drained, moderately rapidly permeable soils that are very shallow to limestone bedrock. These soils are on uplifted plateaus. They formed in sediment overlying porous coralline limestone. Slopes are 0 to 15 percent. The mean annual precipitation is about 229 centimeters, and the mean annual temperature is about 26 degrees C.

Taxonomic class: Clayey, gibbsitic, nonacid, isohyperthermic Lithic Ustorthents.

Typical pedon: Guam cobbly clay loam, 3 to 7 percent slopes; on a 1-percent slope in an area of grazed shrubland. Textures are apparent field textures.

A—0 to 5 centimeters; dark reddish brown (2.5YR 3/4) cobbly clay loam; moderate very fine granular structure; friable, slightly sticky and slightly plastic; many very fine, fine, medium, and coarse roots; many very fine tubular and interstitial pores; about 10 percent pebbles and 10 percent cobbles; neutral (pH 7.1); abrupt smooth boundary. (4 to 15 centimeters thick)

Bw—5 to 20 centimeters; dusky red (10R 3/4) gravelly clay loam; moderate very fine granular structure; very friable, slightly sticky and slightly plastic; many very fine and fine roots and few medium and coarse roots; common very fine tubular and interstitial pores; pressure faces on peds; about 20 percent pebbles and 5 percent cobbles; mildly alkaline (pH 7.5); abrupt irregular boundary. (10 to 41 centimeters thick)

2R—20 centimeters; very porous coralline limestone.

Type location: Guam; in the northeastern part of Fred Quitigua's farm, about 9 meters southeast of main farm road and 100 meters southwest of northern fenceline; northeast of Yigo Church; lat. 13°31'50' N. and long. 144°54'24' E.

Range in characteristics: These soils are not continuously moist in the moisture control section for 90 to 120 cumulative days, primarily between February and May. They usually are moist from July through December. The soil temperature is 27 to 30 degrees C, and it varies less than 2 degrees between summer and winter. Depth to bedrock is dominantly 10 to 25

centimeters, but it ranges from 5 to 41 centimeters. Content of clay as determined in laboratory tests is 60 to 95 percent, but content as determined by apparent field texture is 35 to 55 percent because of the gibbsitic clay mineralogy.

The A horizon has color of dominantly 2.5YR 3/4 or 5YR 3/3 or 3/4, but it ranges to 2.5YR 3/2, 3/3, 2/4, or 4/4. Texture is gravelly clay loam, cobbly clay loam, or gravelly clay. Structure is granular or subangular blocky. The horizon is 5 to 15 percent cobbles and 10 to 25 percent pebbles. Reaction is neutral or mildly alkaline.

The B horizon has color of dominantly 10R 3/4 or 2.5YR 3/6, but it ranges to 10R 3/6, 2.5YR 3/4 or 4/6, or 5YR 3/4, 4/6, or 4/8. Texture is gravelly clay loam, gravelly silty clay, gravelly clay, or cobbly clay loam. Structure is granular or subangular blocky. The horizon is 5 to 15 percent cobbles and 10 to 25 percent pebbles. Reaction is neutral or mildly alkaline.

A C horizon is present in some pedons. It is intermittent, has hue of 5YR, and is gravelly clay loam.

Inarajan Series

The Inarajan series consists of deep and very deep, somewhat poorly drained, slowly permeable soils on broad valley bottoms and coastal plains. These soils formed in alluvium. Slopes are 0 to 4 percent. The mean annual precipitation is about 229 centimeters, and the mean annual temperature is about 26 degrees C.

Taxonomic class: Very-fine, mixed, nonacid, isohyperthermic Aeric Tropic Fluvaquents.

Typical pedon: Inarajan clay, 0 to 4 percent slopes; in a level area of native pasture consisting of sedges and weeds (*Hyptis* and others). Textures are apparent field textures.

A—0 to 25 centimeters; dark gray (5Y 4/1) clay; many fine red (2.5YR 4/6) mottles; moderate medium subangular blocky structure; very firm, very sticky and very plastic; many very fine, fine, and medium roots; common very fine pores and few fine and medium pores; continuous vertical cracks less than 1.25 centimeters wide; strongly acid (pH 5.3); gradual smooth boundary. (20 to 41 centimeters thick)

C1—25 to 41 centimeters; 50 percent dark yellowish brown (10YR 4/4) and yellowish brown (10YR 5/4) and 50 percent gray (5Y 5/1) clay; some of the gray soil material occurs as fillings and worm casts in coarse pores; moderate fine subangular blocky structure; firm, very sticky and very plastic; common very fine roots and few fine and medium roots; many very fine pores, common fine and medium pores, and few coarse pores; pressure cutans on faces of peds; many worm casts; common thin vertical cracks; medium acid (pH 5.8); clear smooth boundary. (10 to 61 centimeters thick)

C2—41 to 66 centimeters; gray (5Y 5/1) clay; many medium dark yellowish brown (10YR 4/4) and yellowish brown (10YR 5/4) mottles; moderate fine angular blocky structure; firm, very sticky and very plastic; few very fine roots; common very fine, fine, and medium pores and few coarse pores; many pores have black streaks; few fine black manganese nodules; pressure cutans on faces of peds; few slickensides; common thin vertical cracks; slightly acid (pH 6.5); abrupt wavy boundary. (10 to 51 centimeters thick)

C3—66 to 74 centimeters; variegated yellowish brown (10YR 5/4) and yellowish red (5YR 4/8) clay; common fine and medium gray (5Y 5/1) mottles coating walls of pores; massive; friable, sticky and plastic; few very fine roots; common very fine, fine, and medium pores and few coarse pores; slightly acid (pH 6.5); abrupt smooth boundary. (8 to 51 centimeters thick)

C4—74 to 81 centimeters; about 60 percent gray (5Y 5/1) and 40 percent reddish yellow (7.5YR 6/8) clay; massive; friable, sticky and plastic; few very fine roots; many very fine pores, common fine pores, and few medium and coarse pores; neutral (pH 6.8); clear smooth boundary. (8 to 41 centimeters thick)

C5—81 to 102 centimeters; reddish yellow (7.5YR 6/8) clay; common fine gray (5Y 5/1) mottles lining pores; massive; friable, slightly sticky and slightly plastic; few very fine roots; many very fine pores and common fine and few medium pores; neutral (pH 6.8); clear wavy boundary. (0 to 41 centimeters thick)

C6—102 to 145 centimeters; clay that is 60 percent gray (5Y 5/1), 30 percent light olive brown (2.5Y 5/4), and 10 percent common fine streaks of yellowish red (5YR 4/6); moderate fine angular blocky structure; friable, sticky and plastic; few very fine roots; common very fine pores and few fine and medium pores; pressure cutans and small slickensides on faces of peds; neutral (pH 7.1).

Type location: Guam; about 400 meters west-northwest of Inarajan Village, about 200 meters south of the Inarajan River, 24 meters north of a corral on the Alfred Flores Ranch; lat. 13°16'45' N. and long. 144°44'25' E.

Range in characteristics: These soils are saturated most of the time between July and November. The A horizon is dry most of the time between March and June. A water table fluctuates between depths of 51 and 102 centimeters between July and December, and it gradually recedes during the dry season. Occasional, brief periods of flooding occur dominantly between June and November, but they may occur with a typhoon at any time of the year. The soil temperature is 27 to 30 degrees C, and it varies less than 2 degrees between summer and winter. Depth to bedrock is dominantly

more than 152 centimeters, but in some pedons it is 102 centimeters. Hummocks are present only in some areas. Surface cracks in the upper part of the soil are 1.25 to 5 centimeters wide and 20 to 51 centimeters deep, but they are less than 1.25 centimeters wide at a depth of 51 centimeters.

The A horizon has color of 10YR 2/1, 3/1, 3/2, or 4/1 or of 5Y 4/1. Mottles have color of 2/5YR 4/6, of 5YR 4/4 or 4/6, or of 7.5YR 4/4. Texture is dominantly clay or silty clay, but it ranges to sandy clay loam in some areas. Reaction is strongly acid to neutral.

The C horizon commonly has color of 5YR 4/6 or 4/8, of 7.5YR 4/4, 5/6, or 6/8, of 10YR 4/3, 3/4, 4/4, 5/4, 5/6, or 7/6, of 2.5Y 5/4, of 10YR 4/1, 4/2, 5/1, or 5/2, of 2.5Y 5/2, or of 5Y 4/1 or 5/1. Texture is dominantly clay or silty clay, but strata of fine sandy loam, sandy clay loam, silty clay loam, or clay loam are present in some pedons. The horizon is 0 to 5 percent pebbles, mainly below a depth of 102 centimeters. Reaction is medium acid to moderately alkaline. Strata in some pedons are calcareous.

Inarajan Variant

The Inarajan Variant consists of very deep, poorly drained, slowly permeable soils on valley bottoms and coastal plains. These soils formed in alluvium. Slopes are 0 to 3 percent. The mean annual precipitation is about 229 centimeters, and the mean annual temperature is about 26 degrees C.

Taxonomic class: Very-fine, mixed, nonacid, isohyperthermic Tropic Fluvaquents.

Typical pedon: Inarajan Variant mucky clay, 0 to 3 percent slopes. When described, the water table was at a depth of 55 centimeters. Textures are apparent field textures.

A—0 to 5 centimeters; mixed black (10YR 2/1) and dark grayish brown (10YR 2/1, 4/2) mucky clay; strong very fine granular structure; sticky and plastic; many fine and very fine roots; neutral (pH 6.7); clear smooth boundary. (1 to 15 centimeters thick)

Cg1—5 to 40 centimeters; mixed dark grayish brown (10YR 4/2) and dark greenish gray (5BG 4/1) clay; common fine brown (7.5YR 4/4) and strong brown (7.5YR 5/6) mottles along root channels; moderate fine subangular blocky structure; very sticky and very plastic; many fine and very fine roots; neutral (pH 6.7); clear smooth boundary. (3 to 38 centimeters thick)

Cg2—40 to 60 centimeters; dark greenish gray (5BG 4/1) clay; many fine strong brown (7.5YR 5/6) mottles; massive; very sticky and very plastic; few very fine roots; neutral; clear smooth boundary. (5 to 28 centimeters thick)

Cg3—60 to 75 centimeters; mixed dark gray (5Y 4/1) and dark greenish gray (5Y 4/1, 5BG 4/1) clay; many fine brown (7.5YR 4/4) and strong brown (7.5YR 5/6) mottles; massive; very sticky and very plastic; few very fine roots; neutral (pH 6.8); gradual smooth boundary. (5 to 25 centimeters thick)

Cg4—75 to 100 centimeters; mixed dark gray (5Y 4/1) and dark greenish gray (5GY 4/1) clay; few fine strong brown (7.5YR 5/6) mottles along pores; massive; very sticky and very plastic; no roots; neutral (pH 6.8); gradual smooth boundary. (5 to 30 centimeters thick)

Cg5—100 to 130 centimeters; mixed dark gray (5Y 4/1) and dark greenish gray (5GY 4/1) clay; massive; very sticky and very plastic; no roots; slightly acid; (pH 6.3) abrupt smooth boundary. (5 to 38 centimeters thick)

Oe—130 to 150 centimeters; black (N 2/0) and dark brown (7.5YR 3/2) hemic material derived dominantly from woody material, about 20 percent fibers when rubbed; pockets of dark bluish gray (5B 4/1) sandy loam; massive; slightly sticky and slightly plastic; no roots; about 5 percent undecomposed bits of wood; medium acid (pH 5.7); diffuse smooth boundary. (0 to 25 centimeters thick)

2Cg—150 to 160 centimeters; dark bluish gray (5B 4/1) mucky sandy loam; massive; slightly sticky and slightly plastic; no roots; about 5 percent undecomposed bits of wood; medium acid (pH 5.7).

Type location: Guam; on the flood plain of the Gautali, Big Gautali, Tenjo, and Atantano Rivers, near the Gautali River; about 120 meters east of Route 1 (Marine Drive); lat. 13°25'30' N. and long. 144°40'40' E.

Range in characteristics: The water table fluctuates from about 50 centimeters above the surface to 60 centimeters below the surface. The soil temperature is about 27 degrees C throughout the year. The soils are hummocky in some areas. In pedons near the coast, the lower horizons are brackish.

The A horizon has color of 7.5YR 3/2 or of 10YR 2/1, 3/2, or 4/2. Texture is clay, mucky clay, or silty clay. Reaction is neutral or mildly alkaline.

The C horizon dominantly has low chroma. Color of the matrix includes 10YR 2/1, 4/2, or 4/4, 2.5Y 4/4, 5BG 4/1, 5Y 4/1, 5GY 4/1, N 2/0, or 5B 4/1. Mottles have color of 7.5YR 4/4, 5/6, or 5/8 or of 5YR 4/6. Texture is dominantly clay or silty clay. Strata of silt loam, sandy loam, and organic material are present in most pedons. Reaction is medium acid to moderately alkaline.

An O horizon is not present in all pedons. It is less than 25 centimeters thick and commonly is below a depth of 100 centimeters.

Kagman Series

The Kagman series consists of deep and very deep, well drained, moderately slowly permeable soils on uplifted limestone plateaus. These soils formed in sediment overlying argillaceous limestone. Slopes are 0 to 15 percent. The mean annual precipitation is about 229 centimeters, and the mean annual temperature is about 26 degrees C.

Taxonomic class: Very-fine, kaolinitic, isohyperthermic Oxic Paleustalfs.

Typical pedon: Kagman clay in an area of Pulantat-Kagman clays, 0 to 7 percent slopes. Textures are apparent field textures.

Ap—0 to 14 centimeters; dark brown (10YR 3/3) clay; moderate fine subangular blocky structure; friable, sticky and plastic; many very fine and fine roots; many very fine and fine pores; common irregular pieces of Bt1 material; slightly acid (pH 6.4); abrupt smooth boundary. (11 to 20 centimeters thick)

Bt1—14 to 50 centimeters; strong brown (7.5YR 5/6) clay; strong very fine subangular blocky structure; friable, very sticky and very plastic; common very fine roots and few fine roots; common very fine pores and few fine pores; few thin clay films on faces of peds; pressure faces on peds; about 5 percent Ap material in wormholes and pores; neutral (pH 6.8); diffuse boundary. (15 to 51 centimeters thick)

Bt2—50 to 75 centimeters; 50 percent strong brown (7.5YR 5/6) and 50 percent yellowish red (5YR 5/6) clay; strong very fine subangular blocky structure; friable, very sticky and very plastic; common very fine roots; common very fine pores and few fine pores; few fine dark brown patches in wormholes and pores; few thin clay films on faces of peds; pressure faces on peds; slightly acid (pH 6.3); diffuse boundary. (15 to 51 centimeters thick)

Bt3—75 to 100 centimeters; 40 percent red (2.5YR 4/6), 30 percent yellowish red (5YR 5/6), and 30 percent strong brown (7.5YR 5/6) clay; strong very fine subangular blocky structure; friable, very sticky and very plastic; few very fine roots; common very fine pores and few fine pores; few organic stains in pores; pressure faces on peds; few thin clay films on faces of peds; slightly acid (pH 6.4); diffuse boundary. (20 to 61 centimeters thick)

Bt4—100 to 127 centimeters; 40 percent red (2.5YR 4/6), 40 percent yellowish red (5YR 5/6), and 20 percent strong brown (7.5YR 5/6) clay; strong very fine subangular blocky structure; friable, very sticky and very plastic; few very fine roots; common very fine pores and few fine pores; few thin clay films on faces of peds; pressure faces on peds; slightly acid (pH 6.3); clear wavy boundary. (15 to 50 centimeters thick)

Bt5—127 to 150 centimeters; strong brown (7.5YR 5/6) clay; moderate very fine subangular blocky structure; friable, very sticky and very plastic; few very fine roots; many very fine and fine pores; few thin clay films on faces of peds; pressure faces on peds; yellowish red (5YR 5/6) bands 2 centimeters wide that contain many sand-sized black manganese concretions and are at the upper boundary of the horizon; neutral (pH 6.8); abrupt irregular boundary.

R—150 to 170 centimeters; very porous white argillaceous limestone; strong brown to reddish yellow (7.5YR 5/6, 6/6, 7/6) stains in fissures; some Bt5 horizon material in interstices.

Type location: Guam; in the southern part of Malojloj Village in an area of a banana plantation owned by Alfred Flores, 200 meters southeast of the highway and 100 meters north of an abandoned poultry ranch; lat. 13°17'45' N. and long. 144°45'30' E.

Range in characteristics: These soils usually are dry in the moisture control section for 90 to 120 cumulative days, primarily between February and May. The moisture control section usually is moist from July through December. The soil temperature is 27 to 30 degrees C, and it varies less than 2 degrees between summer and winter. Depth to bedrock is 150 to 200 centimeters or more. Content of clay in the argillic horizon is 60 to 90 percent.

The A1 horizon has color of N 2/0 or of 10YR 2/2, 3/2, or 4/2. Texture is silty clay loam, clay loam, silty clay, or clay. Rock fragment content is 0 to 10 percent, mostly pebbles and a few cobbles.

The A2 horizon has color of 10YR 3/1, 3/2, 3/3, or 4/3 or of 7.5YR 3/4. Rock fragment content is 0 to 10 percent, mostly pebbles and a few cobbles.

A transitional AB, BA, A/B, or B/A horizon is present in some pedons.

The B horizon has color of dominantly 7.5YR 5/6, 5/8, or 4/6 or of 10YR 5/6 or 5/8, but it ranges to 7.5YR 4/4, 10YR 6/8 or 4/4, 5YR 4/6, or 2.5YR 4/6. Mottles have color of 2.5YR 3/6, 4/6, 4/8, or 5/8 or of 5YR 4/6 or 5/8. Structure is prismatic parting to subangular blocky. Reaction is neutral to slightly acid.

Pulantat Series

The Pulantat series consists of well drained, slowly permeable soils that are shallow over limestone. These soils are on upland plateaus and hills. They formed in residuum derived from argillaceous coralline limestone. Slopes are 3 to 60 percent. The mean annual precipitation is about 229 centimeters, and the mean annual temperature is about 26 degrees C.

Taxonomic class: Clayey, montmorillonitic, isohyperthermic, shallow Udic Haplustalfs.

Typical pedon: Pulantat clay, 30 to 60 percent slopes; on a 50-percent, west-facing slope in an area under tangantangan (*Leucaena leucocephala*). Textures are apparent field textures.

Oi—3 centimeters to 0; undecomposed leaves, twigs, and tangantangan seed pods.

A1—0 to 3 centimeters; very dark grayish brown (10YR 3/2) silty clay, dark grayish brown (10YR 4/2) dry; strong fine and medium granular structure; slightly hard, firm, sticky and plastic; few fine roots; many very fine and fine interstitial pores; slightly acid (pH 6.5); abrupt smooth boundary. (1 to 5 centimeters thick)

A2—3 to 8 centimeters; black (10YR 2/1) and dark brown (10YR 3/3) clay; moderate medium prismatic structure parting to strong fine and medium subangular blocky; very hard, firm, very sticky and very plastic; common fine and medium roots; common very fine and fine tubular and interstitial pores; cracks about 1.25 centimeters wide; pressure cutans on faces of peds; slightly acid (pH 6.5); abrupt smooth boundary. (5 to 15 centimeters thick)

A/B—8 to 18 centimeters; very dark grayish brown (10YR 3/2) dark brown (10YR 3/3) and brown (7.5YR 4/4) clay; moderate medium subangular blocky structure; very hard, firm, very sticky and very plastic; common fine and medium roots; common fine and very fine tubular and interstitial pores; pressure cutans on faces of peds; common worm casts; few very fine black manganese concretions; neutral (pH 6.6); clear wavy boundary. (0 to 15 centimeters thick)

Bt—18 to 30 centimeters; brown (7.5YR 4/4) clay; weak medium prismatic structure parting to strong fine and medium subangular blocky; hard, friable, very sticky and very plastic; common fine and medium roots; few fine and very fine tubular and interstitial pores; common thin and few moderately thick clay films on faces of peds and many moderately thick clay films lining pores; pressure cutans on faces of peds; few pebbles; few worm casts; mildly alkaline (pH 7.5); gradual irregular boundary. (10 to 30 centimeters thick)

Cr—30 to 63 centimeters; brown (7.5YR 4/4) weathered argillaceous limestone that crushes to extremely gravelly clay; many clay-filled cracks and fissures; few thin clay films; no roots; few fine and very fine interstitial pores; moderately alkaline (pH 8.2).

Type location: Guam; about 0.5 kilometer northeast of Agfayan Bay, on a west-facing slope of Boaga Hill; lat. 13°15'10' N. and long. 144°43'20' E.

Range in characteristics: These soils are not continuously moist in all part of the moisture control section for 90 to 120 cumulative days, primarily between February and May. They usually are moist from July through December. The soil temperature is 27 to 30 degrees C, and it varies less than 2 degrees between summer and winter. Depth to paralithic contact is 25 to 51 centimeters. Content of clay is 70 to 90 percent above the paralithic contact.

The A horizon has color of 5YR 3/3, of 7.5YR 3/2, of N 2/0, or of 10YR 2/1, 2/2, or 3/2. Texture is silty clay or clay. Structure is granular or subangular blocky. The horizon is 0 to 5 percent cobbles and 0 to 10 percent pebbles. Reaction is slightly acid or neutral.

The B horizon has color of 7.5YR 4/4, 5/6, or 5/8 or of 10YR 4/4. Texture is clay or gravelly clay. Structure is prismatic parting to subangular blocky. The horizon is 0 to 5 percent cobbles and 2 to 15 percent pebbles. Reaction is neutral to moderately alkaline.

Ritidian Series

The Ritidian series consists of well drained, moderately rapidly permeable soils that are very shallow to limestone. These soils are on plateaus and escarpments. They formed in slope alluvium, loess, and residuum derived from sediment overlying coralline limestone. Slopes are 3 to 99 percent. The mean annual precipitation is about 229 centimeters, and the mean annual temperature is about 26 degrees C.

Taxonomic class: Clayey-skeletal, gibbsitic, nonacid, isohyperthermic Lithic Ustorthents.

Typical pedon: Ritidian extremely cobbly clay loam in an area of Ritidian-Rock outcrop complex, 3 to 15 percent slopes; on an 8-percent slope in an area under forest. Textures are apparent field textures.

A1—0 to 3 centimeters; dark reddish brown (5YR 3/3) extremely cobbly clay loam, dark reddish brown (5YR 3/4) dry; strong medium granular structure; hard, friable, slightly sticky and slightly plastic; many very fine and fine roots, common medium roots, and few coarse roots; many very fine, fine, and medium pores; about 30 percent pebbles and 40 percent cobbles consisting of angular fragments of porous coralline limestone; sand grains and rock fragments are slightly effervescent; mildly alkaline (pH 7.6); abrupt smooth boundary. (1 to 5 centimeters thick)

A2—3 to 10 centimeters; reddish brown (5YR 4/4) extremely cobbly clay loam, yellowish red (5YR 4/6) dry; weak very fine granular structure; soft, very friable, slightly sticky and slightly plastic; many very fine and fine roots, common medium roots, and few coarse roots; many very fine and few fine interstitial pores; about 30 percent pebbles and 40 percent cobbles, consisting of angular fragments of porous coralline limestone; many very fine nodules that crush to silty clay; slightly effervescent; moderately alkaline (pH 7.9); abrupt irregular boundary. (0 to 23 centimeters thick)

R—10 centimeters; unweathered white coralline limestone; very angular and porous; many cracks and fissures that are stained with soil material and organic material; roots along rock faces.

Type location: Guam; about 2.8 kilometers north of the entrance to Andersen South (Marbo Annex) Air Force Housing area on Route 15, about 180 meters along a jeep road to the east, 9 meters east of the road; lat. 13°31'12' N. and long. 144°53'40' E.

Range in characteristics: These soils are not continuously moist in all parts of the moisture control section for 90 to 120 cumulative days during the year, primarily between February and May. They usually are moist from July through November. The soil temperature is 27 to 30 degrees C, and it varies less than 2 degrees between summer and winter. Content of clay is 35 to 60 percent. Depth to bedrock is dominantly 5 to 10 centimeters, but it ranges to 25 centimeters in pockets.

The A horizon has color of 5YR 2/2, 3/2, 3/3, 3/4, 4/4, or 4/6, of 2.5YR 3/4 or 3/6, or of 7.5YR 3/2. Texture of the fine earth fraction is clay loam or clay. Reaction is neutral or mildly alkaline. Content of rock fragments is 40 to 80 percent, of which about two-thirds is cobbles and one-third is pebbles.

Saipan Series

The Saipan series consists of deep and very deep, moderately permeable, well drained soils on uplifted limestone plateaus. These soils formed in sediment overlying porous coralline limestone. Slopes are 0 to 7 percent. The mean annual precipitation is about 229 centimeters, and the mean annual temperature is about 26 degrees C.

Taxonomic class: Fine, mixed, isohyperthermic Oxic Haplustalfs.

Typical pedon: Saipan silty clay in an area of Guam-Saipan complex, 0 to 7 percent slopes. Textures are apparent field textures.

A1—0 to 15 centimeters; dark reddish brown (5YR 3/4) silty clay; weak medium subangular blocky structure; hard, firm, sticky and plastic; many very fine and fine roots and few medium roots; many very fine and fine interstitial and tubular pores; few fine coral pebbles; many fine irregular pieces of Bt1 horizon material; neutral (pH 7.2); abrupt smooth boundary. (1 to 15 centimeters thick)

Bt1—15 to 45 centimeters; yellowish red (5YR 4/6) clay; weak very fine subangular blocky structure; friable, sticky and plastic; many very fine roots and few fine roots; many very fine and fine and common medium tubular pores; many thin clay films lining pores; common thin clay films on faces of peds; common moderately thick clay films on vertical cleavage planes; fine and medium pores with organic stains and worm casts; neutral (pH 7.3); diffuse smooth boundary. (8 to 51 centimeters thick)

Bt2—45 to 70 centimeters; yellowish red (5YR 4/6) clay; moderate very fine subangular blocky structure; friable, sticky and plastic; common very fine roots; many very fine, common fine, and few medium tubular pores; many thin clay films lining pores and common thin clay films on faces of peds; common moderately thick clay films on vertical cleavage planes; fine and medium pores with organic stains and some worm casts; neutral (pH 7.1); diffuse smooth boundary. (8 to 61 centimeters thick)

Bt3—70 to 100 centimeters; red (2.5YR 4/6) clay; strong very fine subangular blocky structure; friable, sticky and plastic; few very fine roots; many very fine, common fine, and few medium tubular pores; many thin clay films lining pores and common thin clay films on faces of peds; few vertical fracture planes with many moderately thick yellowish red (5YR 4/6) clay films; fine and medium pores with organic stains and few worm casts; neutral (pH 7.0); diffuse broken boundary. (8 to 71 centimeters thick)

Bt4—100 to 140 centimeters; yellowish red (5YR 4/8) clay; strong very fine subangular blocky structure; friable, sticky and plastic; few very fine roots; many very fine and common fine tubular pores; common thin clay films on faces of peds; many thin clay films lining pores; neutral (pH 6.9).

Type location: Guam; about 1 kilometer north of Talofofo Village, 30 meters from the end of the paved road and about 50 meters west on the Santos property; lat. 13°21'50' N. and long. 144°45'20' E.

Range in characteristics: These soils usually are dry in the moisture control section for 90 to 120 cumulative days, primarily between February and May. The moisture control section usually is moist from July through December. The soil temperature is 27 to 30 degrees C, and varies less than 2 degrees between summer and winter. Depth to bedrock is 100 to 200 centimeters or more. Content of clay in the argillic horizon is 35 to 60 percent in the argillic horizon. The ochric epipedon is 10 to 22 centimeters thick.

The A horizon has color of 5YR 3/3 or 3/4, of 7.5YR 3/2 or 3/4, of 10YR 2/2 or 3/2, or of 2.5YR 2/2 or 3/2. Texture is clay, silty cläy, clay loam, or silty clay loam. Structure is granular or subangular blocky. Rock fragment content is 0 to 10 percent, mostly pebbles and a few cobbles. Reaction is slightly acid to mildly alkaline. In cultivated areas, the horizon is mixed as an Ap horizon. Some areas have a man-deposited very gravelly overburden.

A transitional AB, BA, A/B, or B/A horizon is in some pedons. It is 0 to 30 centimeters thick.

The B horizon has color of dominantly 5YR 4/4, 4/6, or 4/8 or of 2.5YR 4/6, but it ranges to 5YR 3/4, 5/6, or 4/8, 7.5YR 4/4 or 5/8, or 2.5YR 3/4, 3/6, or 4/8.

Texture is clay loam, silty clay, silty clay loam, or clay. Structure is angular or subangular blocky. Reaction is slightly acid to mildly alkaline.

Sasalaguan Series

The Sasalaguan series consists of deep, well drained, slowly permeable soils on volcanic uplands. They formed in residuum derived from marine-deposited tuffaceous sandstone. Slopes are 7 to 15 percent. The mean annual precipitation is about 229 centimeters, and the mean annual temperature is about 26 degrees C.

Taxonomic class: Very-fine, montmorillonitic, isohyperthermic Vertic Haplustalfs.

Typical pedon: Sasalaguan clay, 7 to 15 percent slopes; on an 11-percent, east-facing slope in a field of fallow (weedy). Textures are apparent field textures.

Ap—0 to 13 centimeters; dark brown (7.5YR 3/2) clay; about 20 percent dark reddish brown (5YR 3/4) and 20 percent dark red (2.5YR 3/6) irregular very fine to coarse patches; moderate fine and very fine subangular blocky structure; firm, very sticky and very plastic; many very fine roots and common fine roots; many very fine pores and few fine pores; strong brown (7.5YR 5/8) stains on very fine pores; strongly acid (pH 5.5); clear smooth boundary. (10 to 30 centimeters thick)

Bt1—13 to 41 centimeters; clay that is 60 percent dark red (2.5YR 3/6) and 30 percent brown (7.5YR 5/4) and is 10 percent dark brown (7.5YR 3/2) in pores and along faces of peds; strong very fine and fine angular blocky structure; firm, very sticky and very plastic; common very fine and fine roots; many very fine pores and few fine pores; pressure cutans on faces of most peds; few very fine black brittle manganese concretions; medium acid (pH 6.0); diffuse boundary. (20 to 51 centimeters thick)

Bt2—41 to 71 centimeters; red (2.5YR 4/6) clay; common fine light yellowish brown (10YR 6/4) and very pale brown (10YR 7/4) patches, of which some are elongated and some are reticulated along pores, faces of peds, and fracture planes; strong fine angular blocky structure; firm, very sticky and very plastic; few very fine roots; many very fine pores and common fine pores; few medium black stains in pores and common very fine black stains on faces of peds; pressure cutans on faces of peds; common slickensides; slightly acid (pH 6.4); diffuse boundary. (20 to 51 centimeters thick)

C1—71 to 104 centimeters; red (2.5YR 4/6) saprolite that crushes to clay when rubbed; 20 percent fine and medium light yellowish brown (10YR 6/4) and very pale brown (10YR 7/4) spots reticulated along pores and angled cleavage planes; few very fine roots; many black stains along cleavage planes; pressure cutans on faces of cleavage planes; few very fine black sand-sized manganese concretions in irregular deposits along cleavage planes; slightly acid (pH 6.5); gradual smooth boundary. (3 to 51 centimeters thick)

C2—104 to 119 centimeters; variegated, about 50 percent red (2.5YR 4/6) and 50 percent light yellowish brown (10YR 6/4) and very pale brown (10YR 7/4) saprolite that crushes to clay when rubbed; rock structure apparent; few very fine roots along cleavage planes; common black manganese concretions in irregular deposits along cleavage planes; slightly acid (pH 6.4); clear smooth boundary. (10 to 61 centimeters thick)

C3—119 to 165 centimeters; red (2.5YR 4/8) saprolite that crushes with difficulty to clay loam; tuffaceous rock structure; slightly acid (pH 6.1).

Type location: Guam; about 0.5 kilometer west of Agfayan Bay, south of the Agfayan River, on road behind eel farm; lat. 13°45'45' N. and long. 144°43'40' E.

Range in characteristics: These soils are not continuously moist in all parts of the soil moisture control section for 90 to 120 cumulative days, primarily between February and May. The soils usually are moist from July through December. The soil temperature is 27 to 30 degrees C, and it varies less than 2 degrees between summer and winter. Content of clay in the argillic horizon is 60 to 80 percent, and it is at least 5 percent more than that in the A horizon. Depth to saprolite is 51 to 102 centimeters. Cracks usually are open from February through May, are 1.3 to 5 centimeters wide at the surface (or below an Ap horizon), and extend to the underlying saprolite.

The A horizon has color of 2.5YR 3/6, of 5YR 3/3 or 3/4, of 7.5YR 3/2 or 4/4, or of 10YR 3/2 or 3/3. Texture is silty clay or clay. Structure is granular, angular, or subangular blocky. Reaction is strongly acid to slightly acid.

The B horizon has color of dominantly 2.5YR 3/6 or 4/6, but it ranges to 7.5YR 3/2, 4/4, 5/4, or 5/6 or 10YR 5/6. Reticulate mottles have hue of 7.5YR to 5Y chroma of dominantly 4 but ranging to 2, and value of 5 to 8. Reaction is strongly acid to slightly acid.

The C horizon has hue of dominantly 2.5YR but ranging to 2.5Y. Subordinate colors are highly variable.

Shioya Series

The Shioya series consists of deep and very deep, rapidly permeable, excessively drained soils on coastal strands. These soils formed in water-deposited coral sand. Slopes are 0 to 5 percent. The mean annual precipitation is about 229 centimeters, and the mean annual temperature is about 26 degrees C.

Taxonomic class: Carbonatic, isohyperthermic Typic Ustipsamments.

Typical pedon: Shioya loamy sand, 0 to 5 percent slopes (fig. 14); on a 2-percent, east-facing slope under

a forest of tangantangan (*Leucaena leucocephala*). Textures are apparent field textures.

A1—0 to 15 centimeters; dark brown (10YR 3/3) loamy sand, grayish brown (10YR 5/2) dry; few very fine very dark grayish brown (10YR 3/2) pockets; single grain; loose, nonsticky and nonplastic; many very fine and fine roots and few medium roots; many very fine interstitial pores; about 5 percent fine pebbles and occasional cobbles; moderately saline; violently effervescent; mildly alkaline (pH 7.8); clear smooth boundary. (5 to 15 centimeters thick).

A2—15 to 25 centimeters; dark brown (10YR 4/3) loamy sand, brown (10YR 5/3) dry; few thin discontinuous very pale brown (10YR 7/3) streaks; single grain; loose, nonsticky and nonplastic; common very fine roots and few fine roots; many very fine interstitial pores; about 5 percent fine pebbles and occasional cobbles; moderately saline; violently effervescent; mildly alkaline (pH 7.8); abrupt smooth boundary. (0 to 15 centimeters thick)

C1—25 to 61 centimeters; very pale brown (10YR 7/3, 7/4) sand; irregular wedge-shaped dark brown (10YR 4/3) krotovina 10 centimeters wide in the upper part; massive; soft, very friable, nonsticky and nonplastic; few very fine roots; many very fine interstitial pores; about 5 percent fine pebbles and occasional cobbles; strongly saline; violently effervescent; sand grains are very weakly cemented with carbonate filaments that are visible under a hand lens; few fine light brownish gray (10YR 6/2) organic stains near upper boundary; moderately alkaline (pH 8.3); diffuse smooth boundary. (0 to 40 centimeters thick)

C2—61 to 109 centimeters; very pale brown (10YR 7/3) sand; massive; soft, very friable, nonsticky and nonplastic; many interstitial pores; about 5 percent pebbles and 5 percent cobbles; strongly saline; violently effervescent; sand grains are very weakly cemented with carbonate filaments that are visible under a hand lens; moderately alkaline (pH 8.3); diffuse smooth boundary. (20 to 99 centimeters thick)

C3—109 to 152 centimeters; very pale brown (10YR 8/3, 8/4) sand; color varies with individual grains; massive; slightly hard, friable, nonsticky and nonplastic; many interstitial pores; about 5 percent pebbles and 5 percent cobbles; strongly saline; violently effervescent; sand grains are weakly cemented with filaments and coatings of carbonates that are visible under a hand lens; moderately alkaline (pH 8.4).

Type location: Guam; about 75 meters west of the barren beachline, about 400 meters south of Togcha Cemetery; lat. 13°22'50' N. and long. 144°46'16' E.

Range in characteristics: These soils are usually dry in the moisture control section for 90 to 120 cumulative days, primarily between February and May. The moisture

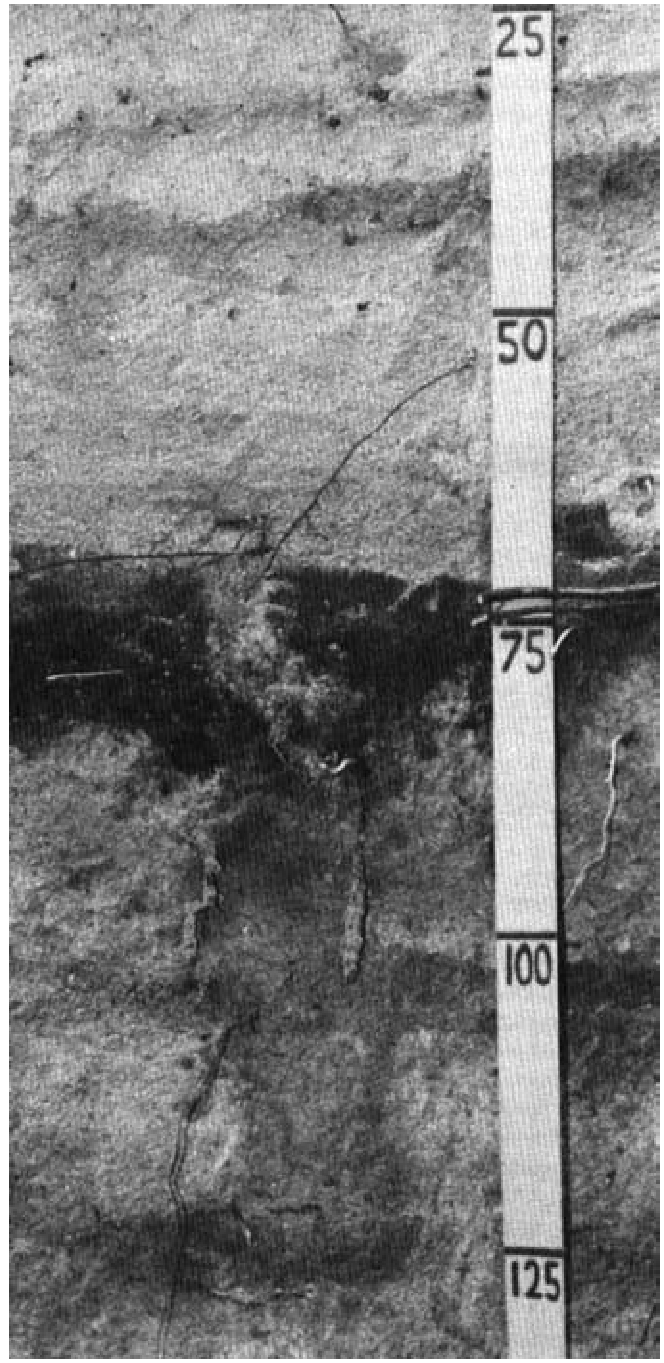


Figure 14.—Profile of Shioya loamy sand, 0 to 5 percent slopes (scale in centimeters). A buried surface layer is present in many areas as a result of sand deposition during storms and typhoons.

control section usually is moist from July through November. The soil temperature is 27 to 30 degrees C, and it varies less than 2 degrees between summer and winter. Depth to contrasting material consisting of very gravelly sand, coralline limestone, or indurated sand dominantly is more than 152 centimeters, but it ranges to as little as 102 centimeters. A buried A horizon is present in some pedons. Weak carbonate cementation is not present in all pedons. Some areas are affected by an oceanic water table that is below a depth of 102 centimeters during periods of high tide.

The A horizon is 5 to 30 centimeters thick. It has color of 10YR 2/1, 3/2, 3/3, 4/2, 4/3, or 5/2. Texture dominantly is loamy sand, but it ranges to sand and sandy loam. The horizon is 1 to 10 percent pebbles and 0 to 5 percent cobbles.

The C horizon has color of 10YR 6/4, 7/2, 7/3, 7/4, 7/6, 8/3, or 8/4 or of 2.5Y 7/2 or 7/4, depending on the color of individual sand grains. Texture dominantly is sand with some strata of loamy sand. Above a depth of 102 centimeters, the horizon is 2 to 10 percent pebbles and 0 to 10 percent cobbles; individual strata are as much as 20 percent pebbles. Below a depth of 102 centimeters, the horizon is 2 to 20 percent pebbles and 0 to 10 percent cobbles; individual strata are as much as 30 percent pebbles and cobbles.

Togcha Series

The Togcha series consists of very deep, well drained, moderately permeable soils on volcanic uplands. These soils formed in slope alluvium derived from weathered tuff and tuff breccia. Slopes are 3 to 15 percent. The mean annual precipitation is about 229 centimeters, and the mean annual temperature is about 26 degrees C.

Taxonomic class: Very-fine, mixed, isohyperthermic Ultic Paleustalfs.

Typical pedon: Togcha silty clay in an area of Togcha-Akina silty clays, 7 to 15 percent slopes; on an 8-percent slope in an area under swordgrass (*Miscanthus floridulus*). Textures are apparent field textures.

A1—0 to 3 centimeters; dark reddish brown (5YR 3/3) silty clay; moderate very fine granular structure; friable, slightly sticky and slightly plastic; common very fine and fine roots; many very fine interstitial pores; strongly acid (pH 5.4); abrupt smooth boundary. (1 to 3 centimeters thick)

A2—3 to 13 centimeters; dark reddish brown (2.5YR 3/4) silty clay; moderate medium and coarse subangular blocky structure parting to moderate very fine and fine subangular blocky; friable, sticky and plastic; many very fine and fine roots and few medium and coarse roots; many very fine and fine, common medium, and few coarse tubular pores; strongly acid (pH 5.4); clear smooth boundary. (8 to 20 centimeters thick)

Bt1—13 to 28 centimeters; dark red (2.5YR 3/6) and yellowish red (5YR 4/6) silty clay; colors occur in a fine reticulate pattern; moderate medium subangular blocky structure parting to moderate very fine subangular blocky; friable, sticky and plastic; many very fine roots and common fine roots; common very fine and fine and few medium tubular pores; common thin clay films on faces of peds and lining pores; few black sand-sized manganese nodules; strongly acid (pH 5.3); clear wavy boundary. (10 to 36 centimeters thick)

Bt2—28 to 36 centimeters; yellowish red (5YR 5/6) and dark red (2.5YR 3/6) silty clay; dark red occurs as fine to medium patches and yellowish red in a fine elongated reticulate pattern; weak very fine subangular blocky structure; friable, sticky and plastic; common very fine roots and few fine roots; many very fine and fine and few medium tubular pores; common thin clay films on faces of peds and lining pores; strongly acid (pH 5.2); clear wavy boundary. (5 to 30 centimeters thick)

Bt3—36 to 71 centimeters; dark red (2.5YR 3/6) silty clay; weak medium subangular blocky structure; very friable, sticky and plastic; common very fine roots; many very fine and fine and few medium tubular pores; few thin clay films on vertical faces of peds; strongly acid (pH 5.4); clear smooth boundary. (0 to 41 centimeters thick)

C1—71 to 81 centimeters; red (2.5YR 4/6) material that is 95 percent sand-sized saprolitic flecks that rub down to silty clay; massive; very friable, sticky and plastic; few very fine roots; many very fine and fine and few medium tubular pores; medium acid (pH 5.6); abrupt smooth boundary. (5 to 51 centimeters thick)

C2—81 to 104 centimeters; dark red (2.5YR 3/6) silty clay; massive; very friable, sticky and plastic; few very fine roots; many very fine and fine and common medium tubular pores; few thin red (2.5YR 4/6) clay films lining pores; strongly acid (pH 5.5); abrupt smooth boundary. (5 to 51 centimeters thick)

C3—104 to 152 centimeters; red (2.5YR 4/6) and dark red (2.5YR 3/6) material that is 90 percent sand-sized saprolitic flecks and 3 percent fine pebble-sized saprolitic flecks that rub down to silty clay; massive; very friable, sticky and plastic; few very fine roots; many very fine and fine and common medium tubular pores; one thin strata contains black grains; medium acid (pH 5.6).

Type location: Guam; Ija Experiment Station, near future pond site, about 130 meters northeast of the end of the paved road; lat. 13°16'30' N. and long. 144°42'52' E.

Range in characteristics: These soils are not continuously moist in all parts of the soil moisture control section for 90 to 120 cumulative days, primarily between

February and May. The soils usually are moist from July through December. The soil temperature is 27 to 30 degrees C, and it varies less than 2 degrees between summer and winter. A buried A horizon is present in some pedons. Grayish brown (10YR 5/2) mottles and manganese stains are below a depth of 102 centimeters in some pedons.

The A horizon has color of 2.5YR 3/4, of 5YR 3/3 or 3/4, or of 7.5YR 3/2. Texture is silty clay loam or silty clay. Structure is granular or subangular blocky. Reaction is strongly acid or medium acid.

The B horizon has color of 2.5YR 3/4, 3/6, or 4/6 or of 5YR 4/4, 4/6, or 5/6. Texture is silty clay or clay. Clay content is 60 to 80 percent. Reaction is strongly acid or medium acid.

The C horizon has color of 2.5YR 3/4, 3/6, or 4/6 or of 5YR 4/4, 4/6, 4/8, or 5/6. Texture is silty clay or clay. Reaction is strongly acid or medium acid.

Yigo Series

The Yigo series consists of deep and very deep, well drained, moderately permeable soils in depressional areas on plateaus. These soils formed in sediment overlying porous coralline limestone. Slopes are 0 to 7 percent. The mean annual precipitation is about 229 centimeters, and the mean annual temperature is about 26 degrees C.

Taxonomic class: Clayey, gibbsitic, isohyperthermic Tropeptic Eutrustox.

Typical pedon: Yigo silty clay in an area of Guam-Yigo complex, 0 to 7 percent slopes; on a concave, 2-percent slope in a fallowed, weedy field. Textures are apparent field textures.

Ap—0 to 15 centimeters; dark reddish brown (2.5YR 3/4) silty clay; moderate very fine granular structure; very friable, slightly sticky and slightly plastic; common very fine and fine roots; many very fine interstitial pores; slightly acid (pH 6.5); abrupt smooth boundary. (10 to 30 centimeters thick)

Bo1—15 to 41 centimeters; dusky red (10R 3/4) silty clay; moderate very fine subangular blocky structure; very hard, very friable, slightly sticky and slightly plastic; common very fine roots; many very fine and few fine tubular and interstitial pores; all faces of peds are shiny; few thin pressure faces in pores; some organic stains in pores; neutral (pH 6.8); diffuse smooth boundary. (20 to 102 centimeters thick)

Bo2—41 to 150 centimeters; dark red (10R 3/6) silty clay; moderate very fine subangular blocky structure; very hard, very friable, slightly sticky and slightly plastic; few very fine roots; many very fine and few fine tubular and interstitial pores; all faces of peds are shiny; few thin pressure faces in pores; some organic stains in pores; neutral (pH 6.8).

Type location: Guam; Fred Quitigua's farm, along central, northeast-trending farm road, about 300 meters from back fenceline and 30 meters northwest of road; about 2.7 kilometers northeast of Yigo Village; lat. 13°31'50' N. and long. 144°51'24' E.

Range in characteristics: These soils are not continuously moist in all parts of the soil moisture control section for 90 to 120 cumulative days, primarily between February and May. The soils usually are moist from July through December. The soil temperature is 27 to 30 degrees C, and it varies less than 2 degrees between summer and winter. Depth to bedrock dominantly is more than 152 centimeters, but it ranges to as little as 102 centimeters. The control section is 40 to 60 percent clay.

The A horizon has color of 10R 3/3 or 2.5YR 3/4. Texture is clay or silty clay. The horizon is 0 to 5 percent pebbles. Reaction is medium acid or slightly acid in undisturbed areas, but is neutral or mildly alkaline in farmed and limed areas.

The B horizon has color of 10R 3/4 or 3/6. Rock fragment content is 0 to 5 percent, mostly pebbles and a few cobbles. Reaction is slightly acid to mildly alkaline.

Ylig Series

The Ylig series consists of very deep, somewhat poorly drained, moderately slowly permeable soils in seep areas on concave hillsides and in drainageways. These soils formed in alluvium derived from weathered tuff and tuff breccia. The soils are hummocky in some areas. Slopes are 0 to 15 percent. The mean annual precipitation is about 229 centimeters, and the mean annual temperature is about 26 degrees C.

Taxonomic class: Fine, mixed, acid, isohyperthermic Aquic Ustifluvents.

Typical pedon: Ylig clay, 0 to 3 percent slopes; on a nearly level slope in a ravine under forest dominated by screw pine (*Pandanus fragrans*) and sea hibiscus (*Hibiscus tiliaceus*) with kariso (*Phragmites karka*) in channels. Textures are apparent field textures.

A1—0 to 13 centimeters; dark brown (7.5YR 3/2) clay; moderate fine subangular blocky structure; hard, firm, sticky and plastic; many very fine, fine, medium, and coarse roots; many fine interstitial pores; many cracks less than 1.25 centimeters across; common pressure faces; few worm casts; slightly acid (pH 6.3); clear wavy boundary. (5 to 20 centimeters thick)

C1—13 to 36 centimeters; dark brown (7.5YR 4/4) clay loam; about 5 percent fine yellowish red (5YR 4/6) and yellowish brown (10YR 5/4) patches; massive; friable, sticky and plastic; common very fine, fine, medium, and coarse roots; many fine interstitial pores; medium acid (pH 5.6); diffuse boundary. (10 to 41 centimeters thick)

C2—36 to 56 centimeters; about 50 percent dark brown (7.5YR 4/4) clay loam and 50 percent dark reddish brown (5YR 3/4), brown (10YR 5/3), and black (10YR 2/1) silty clay in a very fine pattern; weak subangular blocky structure; friable, sticky and plastic; many very fine and fine roots and few medium and coarse roots; many large interstitial pores; medium acid (pH 5.6); abrupt wavy boundary. (5 to 41 centimeters thick)

C3—56 to 76 centimeters; grayish brown (10YR 5/2), brown (10YR 5/3), and yellowish brown (10YR 5/4) silty clay; common very fine reddish brown (5YR 4/4) and dusky red (2.5YR 3/2) mottles along faces of peds; moderate very fine subangular blocky structure; very friable, sticky and plastic; common very fine, fine, and medium roots; many large pores, mostly interstitial; strongly acid (pH 5.3); abrupt smooth boundary. (15 to 61 centimeters thick)

C4—76 to 99 centimeters; grayish brown (10YR 5/2) clay; about 40 percent very fine dark reddish brown (2.5YR 2/4) and dark red (2.5YR 3/6) mottles; few black (10YR 2/1) stains on faces of peds and lining pores; strong very fine subangular blocky structure; friable, very sticky and very plastic; common very fine and fine roots; many large interstitial pores; strongly acid (pH 5.2); abrupt smooth boundary. (15 to 51 centimeters thick)

C5—99 to 104 centimeters; reddish gray (5YR 5/2) clay loam; few medium strong brown (7.5YR 5/6) mottles; massive; very friable, slightly sticky and slightly plastic; common very fine and fine roots; many large pores; strongly acid (pH 5.2); abrupt smooth boundary. (5 to 41 centimeters thick)

C6—104 to 114 centimeters; 60 percent grayish brown (10YR 5/2) and 40 percent dark red (2.5YR 3/6) clay; moderate fine subangular blocky structure; friable, very sticky and very plastic; common very fine and fine roots; few very fine pores with black coatings; few white saprolitic sand grains; very strongly acid (pH 4.8); abrupt wavy boundary. (0 to 41 centimeters thick)

C7—114 to 140 centimeters; yellowish red (5YR 5/8) clay loam; few fine dark red (2.5YR 3/6) and grayish brown (10YR 5/2) mottles along pores; massive; friable, sticky and plastic; common very fine and fine roots; many fine pores; very strongly acid (pH 4.5); abrupt wavy boundary. (0 to 30 centimeters thick)

C8—140 to 160 centimeters; grayish brown (10YR 5/2) clay; few fine dark red (2.5YR 3/6) mottles along pores; weak very fine subangular blocky structure; firm, very sticky and very plastic, common very fine bits of charcoal and very thin intermittent layers of charcoal; very strongly acid (pH 4.6).

Type location: Guam; about 1.5 kilometers west of Agfayan Bay, along a tributary of the Agfayan River; lat. 13°16'0' N. and long. 144°43'20' E.

Range in characteristics: These soils usually are saturated for extended periods during July through November. The upper part of the soils usually is dry from February through May. A water table fluctuates between depths of 25 and 102 centimeters during the rainy season, and it recedes during the dry season. Flooding is rare or common. The soil temperature is 27 to 30 degrees C, and it varies less than 2 degrees between summer and winter. The control section is 35 to 60 percent clay.

The A horizon has color of 7.5YR 3/2 or of 10YR 2/1, 3/1, 3/2, or 3/3. Texture is silty clay or clay. Reaction is strongly acid to slightly acid. Mottles that have color of 7.5YR 4/4 are present in some pedons. Recent overwash that has color of 5YR 3/4 or 4/6 or of 10YR 3/4 or 4/4 is present in some pedons.

The C horizon has colors in both high and low chroma. Subordinate colors are present in a reticulate pattern along pores and on faces of peds. High chroma colors dominantly are in hue of 2.5YR or 5YR but range to 10YR. They have value of 2 to 5 and chroma of 2 to 6. Low chroma colors are in hue of 2.5YR, 5YR, 7.5YR, 10YR, 2.5Y, or 5Y. They have value of 4 to 6 and chroma of 1 or 2. Texture is clay, silty clay, or clay loam. Rock fragment content is 0 to 10 percent. Reaction is very strongly acid to medium acid.

Formation of the Soils

Soil is a natural, three-dimensional body on the Earth's surface that supports or is capable of supporting plants. Physical and chemical processes have determined its morphology. These processes have resulted from the interaction of five factors—parent material, climate, living organisms, topography, and time. Differences among soils can be traced to differences in one or more of these factors. The following section discusses each of these factors and explains how their interactions have formed the soils on Guam.

The discussion considers each factor separately, but a soil is the result of the interactions of all five of these factors.

Parent Material

Parent material is the single most important soil-forming factor that can be used to explain the differences among the soils on Guam.

Basically, Guam is constructed of a series of volcanic deposits, upon and around which limestone has been deposited (*19*). The volcanic deposition occurred during the Eocene, Oligocene, and Miocene epochs. The material is primarily andesite with some basaltic flows, and it was deposited as tuff, tuff breccia, tuffaceous sandstone and shale, volcanic conglomerate, and basalt flows. Most of this material was deposited in the ocean, and many of the facies are cemented by calcite. Fragments of limestone are present in most of the conglomerate and breccia. Lenses and beds of limestone are intermittently present within these volcanic members.

Most of the limestone deposition occurred during the Pliocene and Pleistocene epochs. The limestone is primarily reef complex and reef detritus. Important components include foraminiferal, molluscan, argillaceous, detrital, reef, and fore-reef facies.

Uplifting, folding, and faulting occurred throughout the volcanic period. The basic shape of the island was intact by late Miocene time. Much of the volcanic deposits were at least temporarily above sea level by this time and were subject to weathering and erosion. Some erosional products were incorporated into the limestone lagoonal deposits, producing argillaceous limestone. Emergence and movements of the island continued into Pleistocene time. During the Holocene epoch the alluvial valley fill and strandline sediment have been and are continuing to be deposited.

There is a distinct difference between the residual soils derived from limestone, such as the Guam and Pulantat soils, and those that developed in volcanic material, such as the Akina, Atate, and Agfayan soils. The limestone soils generally are higher in content of calcium and have neutral to moderately alkaline reaction. The volcanic Akina and Atate soils, however, are strongly acid and are low in content of calcium.

The main residual volcanic soils are those of the Akina and Agfayan series. Although there is good correlation between these soils and areas mapped as volcanic (*19*), there is no correlation between the kind of soil and a specific volcanic member. Both Akina and Agfayan soils are present on all ages and facies of volcanic rock. For some reason, the parent material of the Agfayan soils is less weathered than that of the Akina soils. In many areas this is probably attributable to differences in the parent material itself. The substratum of the Agfayan soils is more resistant to weathering, perhaps because it includes more calcite, which acts as a cementing agent. Agfayan soils are higher in content of calcium and other bases than are the Akina soils and contain montmorillonite, which forms in high base environments.

Of the various facies of limestone mapped, the most important distinction from a soils standpoint is the purity of the limestone. A "pure" limestone will weather to carbon dioxide and water saturated with calcium carbonate. Thus, the impurities in the limestone constitute the residual limestone soil. The limestone that underlies the Guam cobbly clay loam generally has about 0.1 percent impurities (*4*). The Guam soils are 10 to 25 centimeters thick; therefore, if these soils are derived entirely from the present underlying material, a thickness of 100 to 250 meters of limestone must have dissolved since the limestone emerged during the Pleistocene. This seems excessive. For this reason, many believe that the Guam soils are derived from a volcanic ashfall that blanketed the limestone. However, such an ashfall would have covered other landscapes as well, and there is no evidence of a contrasting volcanic layer in the other soils of the island. Another possibility is that the upper layers of these limestone facies had a higher content of impurities than does the presently exposed limestone. Whatever the source, the intense weathering coupled with the moderately rapid permeability of the underlying limestone has resulted in

the removal of silica from the Guam soils and the residual accumulation of iron oxides and gibbsite.

Argillaceous limestone has an appreciable amount of clay impurities, which remain upon dissolution of the limestone to produce soil. Pulantat, Kagman, and some Chacha soils formed in material derived from argillaceous limestone. The Kagman and Chacha soils have kaolinitic mineralogy in contrast to the gibbsitic mineralogy of the Guam and Yigo soils, which are underlain by pure limestone. This is attributable to the nature of the limestone. The clay in the argillaceous limestone is not so permeable as is the same material derived from the purer limestone. Upon weathering, silica is not removed rapidly from the soils as was the case in the formation of the highly permeable Guam soils. Thus, the silica released combines with aluminum to form kaolinite, and the kaolinitic clay of the argillaceous limestone cannot be desilicified to form gibbsite (*4*).

Another important parent material on Guam is alluvium. The uplifted, tilted, and strongly dissected volcanic uplands of southern Guam produce an abundance of alluvium. Some of this material has been deposited directly downslope in upland basins and valleys; this is the parent material of the Togcha soils. The Ylig soils also formed in upland volcanic alluvium, but the material generally has moved further and is on valley bottoms. The Inarajan soils formed in alluvium that has moved downstream and has been deposited in wide valley mouths and coastal plains.

The Togcha, Ylig, and Inarajan soils formed in clayey alluvial parent material; the Shioya soils formed in sand. These sands are beach deposits derived from limestone that has been physically weathered to sand and deposited along the coast by waves and currents. Wind is not considered to have been an important depositional force, because no dunes are present.

Some of the deep limestone soils in depressional areas, such as the Yigo soils, were formed partly by the gradual erosion of the surrounding shallower upslope soils by wind and water.

Organic matter is the parent material of the Troposaprists in Agana Swamp. Over thousands of years, kariso (*Phragmites karka*), sedges, and other species have deposited leaves, stems, and roots in the swamp waters. Because of the anaerobic conditions created by the permanently high water table, the rate of organic matter deposition is faster than the rate of decomposition; therefore, organic matter has accumulated.

Climate

The climate on Guam is uniformly warm and humid throughout the year, with distinct seasonal wet and dry seasons. The higher elevations on Guam are moister and slightly cooler than the lower areas; however, this difference has not been great enough to create different soils at the higher and lower elevations. The high temperatures and precipitation on Guam have resulted in a strong weathering regime. Physical and biological processes break down the parent material and release the products of this breakdown into the soil solution. Many of these weathering products recombine into more resistant secondary minerals. Other soluble materials are leached out of the soil profile during the rainy season. Over time, only the most resistant primary minerals and most stable secondary minerals remain in the soil.

Most of the well drained upland soils on Guam, such as those of the Akina and Yigo series, are highly weathered and leached. Soluble bases such as calcium and magnesium have been leached from these soils. Primary minerals have weathered to release iron, silica, and aluminum. Iron has formed very stable secondary minerals of iron oxide, which gives these soils their characteristic red color. In the Akina soils, the silica and aluminum released from the primary rock minerals have recombined to form the secondary clay mineral of kaolinite. In the Yigo soils, even the silica has been leached away and the aluminum has formed the very stable hydroxides of gibbsite. The Yigo soils are a good example of the result of climatic soil weathering; these soils are composed primarily of very stable oxides and hydroxides of iron and aluminum.

The high rainfall and leaching cause clay minerals to move from the surface layer into the subsoil. During the dry season, the soils dry out because evapotranspiration exceeds precipitation. As the soil dries, the clay particles are deposited in the pores and along the ped faces of the subsoil. After a long period of time, distinct clay films are formed. Clay films are common in Akina, Atate, Kagman, Togcha, and other upland soils on Guam. Clay films are absent, however, in the Guam and Yigo soils.

Living Organisms

This factor includes the effects of vegetation, animals, and man on the formation of soils. First, vegetation stabilizes sloping landscapes and helps to prevent massive soil movements such as slumping and erosion. This is a very important aspect of vegetation on sloping volcanic soils such as those of the Agfayan, Akina, and Togcha series. Second, vegetation decomposes in the soil to form organic matter. This organic matter binds soil particles into stable aggregates, increases soil water-holding capacity and infiltration rates, and slowly releases soil nutrients over time. In Guam, the surface layer of most soils is relatively high in content of organic matter, ranging from about 3 to 8 percent; however, this layer is thin and generally does not exceed 20 centimeters. Dark colors generally are associated with high organic matter content, but in the tropics this correlation is poor. In the highly leached upland soils of Guam, organic matter provides most of the nutrients required for plant growth. This is particularly true in the

Yigo soils, which would be virtually inert without organic matter.

The role of vegetation in soil and landscape development is most pronounced on the Akina soils in southern Guam. These soils formed in saprolite tuff that has been deeply weathered to form clay. The continual downcutting of streams has created steep side slopes. Heavy rains saturate the clayey saprolite with water, and slumping occurs on the steeper side slopes. The resulting badland scar is subject to severe erosion. Gradually, pioneering plant species such as savannah fern *Gleichenia linearis* become established on the badland and provide conditions for grasses and forbs to germinate and grow. Although the steep headwall of the badland may continue to slump, most of the badland will eventually "heal" under natural conditions and become young savannah soils. If these savannah soils are stable over a long period of time, they will develop into Akina soils. Shrubs such as *Glochidion marianum* and *Melastoma marianum* may appear among the savannah grasses; trees such as *Pandanus fragrans* and ironwood (*Casuarina equisetifolia*) may invade the site. Eventually, if there is no disruption from fire or further slumping, a forest will develop.

The effects of the forest vegetation on these soils is, in some ways, significantly different than those of the savannah. Very few slumps (badlands) can be observed on the forested Akina and Atate soils. This may be due in part to the effective binding strength of the extensive, woody tree roots. In addition, water lost from the forest system, both as runoff and as infiltration, is substantially less than that lost from the savannah (*14*). Thus, the forest may be effectively "dewatering" the soil, thereby preventing the loss of strength and subsequent slumping that is common in savannahs.

Field observations suggest that the reaction of the surface layer is higher in areas of forested Akina and Atate soils than it is in areas of Akina and Atate soils under savannah vegetation. Another observation is that the wildfires that frequently burn the savannahs stop at the forest boundary, generally scorching only the peripheral trees. As a result of the fire, all of the bases stored in the savannah vegetation are solubilized and deposited on the bare soil surface, subject to the intense leaching and erosive forces of the rainfall. This process does not occur on forested sites. The effects of fire, combined with the lower biomass production of the savannah (*14*) and the higher runoff and leaching rates, may account for the more highly leached surface layer in the savannah soils as compared with forested soils within the same soil series.

The factor of living organisms on the soils of Guam includes the effects of man. In addition to the physical effects of bulldozing, scraping, spreading gravel, and pouring concrete, man affects the soils in many other ways. Most of the wildfires in southern Guam are attributable to man; these fires significantly affect soil erosion and plant succession. Off-road vehicles have a similar, although highly localized, effect.

Topography

Topography is the relief features or surface configuration of the landscape. Topography is the result of geological forces such as uplift, folding, and faulting as well as geomorphic processes such as erosion and deposition.

The uplifted, faulted landscape of southern Guam has been deeply dissected by rivers. The resulting topography includes many steep slopes. The Akina and Agfayan soils, which occur on these slopes, are continually subject to erosion and slumping. Thus, topography is in part responsible for the very shallow depth of the Agfayan soils and for the badland slumps on the Akina soils.

Erosion products, or alluvium, from these soils are deposited in various positions downslope, depending on the topographic gradients and the flow of the alluvium-laden water. The Ylig and Inarajan soils formed in alluvium from the surrounding uplands.

The distribution of the deep soils that formed in material weathered from limestone is also controlled by topography to varying degrees. The Yigo soils are in depressional areas, where erosional products have gradually accumulated. Kagman and Saipan soils are in low-lying areas that accumulate sediment, but they are also in nearly level to gentle sloping areas where alluvial accumulations have probably been minimal. The topographic stability of these areas has allowed for deep weathering of the argillaceous parent material with no erosional losses. On steeper slopes, only the shallow Pulantat soils occur.

The distribution of the sandy Shioya soils is directly related to topography. Only in those areas that are subject to sand deposition can Shioya soils form.

Internal drainage is an important soil characteristic related to topographic position. During the rainy season, soils in low topographic positions receive runoff from higher areas. In slowly permeable, nearly level soils, this creates a seasonal or permanent water table. The Ylig, Inarajan, Chacha, and Chacha Variant soils have a seasonal water table. The Inarajan Variant soils and Troposaprists have a permanent water table. The presence of the water table influences soil development.

In these soils, the intense weathering due to the climate is not accompanied by the leaching of weathering products, as occurs in the uplands. As a result, montmorillonitic clay minerals tend to form or persist, and bases such as calcium and magnesium are not removed. In parts of the soil that are saturated for extended periods, iron is reduced. Reduced iron is bluish or greenish gray and is soluble, in contrast to the reddish or yellowish, insoluble, oxidized forms. This reduced iron will move about in the soil according to the complex

chemical gradients that are present. In the permanently wet Inarajan Variant soils, these reduced iron colors or gleyed colors can easily be seen. In seasonally wet soils, such as those of the Inarajan series, evidence of iron reduction can be seen in the mottled colors. Reddish mottles are areas where the reduced, soluble iron has accumulated and been oxidized. Dull grey mottles are areas where iron has been removed or reduced, or both.

A similar reduction-oxidation cycle occurs with manganese; instead of mottles, however, manganese tends to accumulate as concretions. The many black manganese concretions present in the Chacha soil are the result of a seasonal high water table and associated reduction-oxidation reaction.

Topographic depressional areas are not always seasonally wet. In permeable soils that have a permeable substratum, water does not accumulate for periods of time long enough to create reducing conditions. Yigo soils and some areas of Saipan soils are good examples of this.

Time

Soil development, by human standards, is a slow process. Time is necessary for rocks to weather into soil and for soil to develop distinct horizons. In some soils, erosion keeps pace with rock weathering so that the soils are always young. This is part of the reason why the Agfayan soils are so shallow and lack subsoil development. In other areas, deposition continually replenishes the soils. This is true of the youthful Inarajan soils.

In terms of soil development, time moves quickly in the tropics. High rainfall and constant high temperatures have resulted in relatively rapid soil development on the stable topographic surfaces in Guam. The Yigo and Saipan soils have physical and chemical soil properties that can only develop over a long period of time. Even the Akina soils, although not on a particularly stable landscape, have highly leached and weathered properties associated with an "old" soil.

Generally, the age of the parent material is related to the age and subsequent development of the corresponding soil. In many instances, the relative age of the different landscape units, or geomorphic surfaces, is directly related to differences in soil development. On Guam, for example, one would expect to find deeper and more strongly developed soils on the older limestone terraces than in areas of younger limestone; however, this does not seem to be the case. The stability of the surface combined with the nature of the parent material determines the relative rates of soil development on Guam.

For example, the Facpi volcanic formation contains the oldest rock on Guam; however, this rock is very resistant to weathering. Folding, faulting, and dissection have created steep slopes that are subject to high runoff and erosion. The Agfayan soils, which are dominant on this landscape, have characteristics of young soils. They are shallow, are high in content of bases, are dominated by montmorillonitic clay, and have little or no subsoil development.

On the other hand, the Marianas and Barrigada Limestones of the northern plateau are younger than the volcanic rock. The Yigo soils formed in depressional areas on this plateau. Because the limestone is permeable, the weathering products have been rapidly removed from these soils. The resulting low cation-exchange capacity and gibbsitic mineralogy are characteristics of very old soils.

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Glossary

Aeration, soil. The exchange of air in soil with air from the atmosphere. The air in a well aerated soil is similar to that in the atmosphere; the air in a poorly aerated soil is considerably higher in carbon dioxide and lower in oxygen.

Aggregate, soil. Many fine particles held in a single mass or cluster. Natural soil aggregates, such as granules, blocks, or prisms, are called peds. Clods are aggregates produced by tillage or logging.

Alluvium. Material, such as sand, silt, or clay, deposited on land by streams.

Andesite. Fine-grained, extrusive volcanic rock of intermediate silica content.

Area reclaim (in tables). An area difficult to reclaim after the removal of soil for construction and other uses. Revegetation and erosion control are extremely difficult.

Argillaceous limestone. Limestone containing an appreciable (but less than 50 percent) amount of clay.

Association, soil. A group of soils or miscellaneous areas geographically associated in a characteristic repeating pattern and defined and delineated as a single map unit.

Available water capacity (available moisture capacity). The capacity of soils to hold water available for use by most plants. It is commonly defined as the difference between the amount of soil water at field moisture capacity and the amount at wilting point. It is commonly expressed as centimeters of water per centimeter of soil. The capacity, in centimeters, in a 150-centimeter profile or to a limiting layer is expressed as—

	Centimeters
Very low	0 to 8
Low	8 to 15
Moderate	15 to 23
High	23 to 30
Very high	More than 30

Basalt. Fine-grained extrusive volcanic rock of low silica content.

Base saturation. The degree to which material having cation exchange properties is saturated with exchangeable bases (sum of Ca, Mg, Na, K), expressed as a percentage of the total cation exchange capacity.

Bedrock. The solid rock that underlies the soil and other unconsolidated material or that is exposed at the surface.

Bottom land. The normal flood plain of a stream, subject to flooding.

Breccia. Coarse-grained clastic rock composed of large, angular, and broken rock fragments that are cemented together in a fine-grained matrix.

Calcareous soil. A soil containing enough calcium carbonate (commonly combined with magnesium carbonate) to effervesce visibly when treated with cold, dilute hydrochloric acid.

Canopy. The leafy crown of trees or shrubs. (See Crown.)

Cation. An ion carrying a positive charge of electricity. The common soil cations are calcium, potassium, magnesium, sodium, and hydrogen.

Cation-exchange capacity. The total amount of exchangeable cations that can be held by the soil, expressed in terms of milliequivalents per 100 grams of soil at neutrality (pH 7.0) or at some other stated pH value. The term, as applied to soils, is synonymous with base-exchange capacity, but is more precise in meaning.

Clay. As a soil separate, the mineral soil particles less than 0.002 millimeter, in diameter. As a soil textural class, soil material that is 40 percent or more clay, less than 45 percent sand, and less than 40 percent silt.

Clay film. A thin coating of oriented clay on the surface of a soil aggregate or lining pores or root channels. Synonyms: clay coating, clay skin.

Coarse fragments. Mineral or rock particles larger than 2 millimeters in diameter.

Cobble (or cobblestone). A rounded or partly rounded fragment of rock 7.6 to 25 centimeters in diameter.

Cobbly soil material. Material that is 15 to 35 percent, by volume, rounded or partially rounded rock fragments 7.5 to 25 centimeters in diameter. Very cobbly soil material is 35 to 60 percent of these rock fragments, and extremely cobbly soil material is more than 60 percent.

Colluvium. Soil material, rock fragments, or both, moved by creep, slide, or local wash and deposited at the base of steep slopes.

Complex, soil. A map unit of two or more kinds of soil or miscellaneous areas in such an intricate pattern

or so small in area that it is not practical to map them separately at the selected scale of mapping. The pattern and proportion of the soils or miscellaneous areas are somewhat similar in all areas.

Compost. Mixture of various decaying organic substances, such as dead leaves and manure, used for fertilizing land.

Concretions. Grains, pellets, or nodules of various sizes, shapes, and colors consisting of concentrated compounds or cemented soil grains. The composition of most concretions is unlike that of the surrounding soil. Calcium carbonate and iron oxide are common compounds in concretions.

Conglomerate. A coarse grained, clastic rock composed of rounded to subangular rock fragments more than 2 millimeters in diameter. It commonly has a matrix of sand and finer material. Conglomerate is the consolidated equivalent of gravel.

Consistence, soil. The feel of the soil and the ease with which a lump can be crushed by the fingers. Terms commonly used to describe consistence are—

Loose.—Noncoherent when dry or moist; does not hold together in a mass.

Friable.—When moist, crushes easily under gentle pressure between thumb and forefinger and can be pressed together into a lump.

Firm.—When moist, crushes under moderate pressure between thumb and forefinger, but resistance is distinctly noticeable.

Plastic.—Readily deformed by moderate pressure but can be pressed into a lump; will form a "wire" when rolled between thumb and forefinger.

Sticky.—Adheres to other material and tends to stretch somewhat and pull apart rather than to pull free from other material.

Hard.—When dry, moderately resistant to pressure; can be broken with difficulty between thumb and forefinger.

Soft.—When dry, breaks into powder or individual grains under very slight pressure.

Cemented.—Hard; little affected by moistening.

Control section. The part of the soil on which classification is based. The thickness varies among different kinds of soil, but for many it is that part of the soil profile between depths of 25 centimeters and 100 or 200 centimeters.

Corrosive. High risk of corrosion to uncoated steel or deterioration of concrete.

Cover crop. A close-growing crop grown primarily to improve and protect the soil between periods of regular crop production, or a crop grown between trees and vines in orchards and vineyards.

Crop residue management. Returning crop residue to the soil, which helps to maintain soil structure, organic matter content, and fertility and helps to control erosion.

Cropping system. Growing crops using a planned system of rotation and management practices.

Cross-slope farming. Deliberately conducting farming operations on sloping farmland in such a way that tillage is across the general slope.

Crown. The upper part of a tree or shrub, including the living branches and their foliage.

Cutbanks cave (in tables). The walls of excavations tend to cave in or slough.

Depth to rock (in tables). Bedrock is too near the surface for the specified use.

Detritus. Loose rock and mineral material that is worn off or removed directly by mechanical means and moved from its place of origin.

Dissection. The work of streams in cutting or dividing the land into hills and ridges, or into flat upland areas, separated by fairly close networks of valleys.

Diversion (or diversion terrace). A ridge of earth, generally a terrace, built to protect downslope areas by diverting runoff from its natural course.

Drainage class (natural). Refers to the frequency and duration of periods of saturation or partial saturation during soil formation, as opposed to altered drainage, which is commonly the result of artificial drainage or irrigation but may be caused by the sudden deepening of channels or the blocking of drainage outlets. Seven classes of natural soil drainage are recognized:

Excessively drained.—These soils have very high and high hydraulic conductivity and low water holding capacity. They are not suited to crop production unless irrigated.

Somewhat excessively drained.—These soils have high hydraulic conductivity and low water holding capacity. Without irrigation, only a narrow range of crops can be grown and yields are low.

Well drained.—These soils have intermediate water holding capacity. They retain optimum amounts of moisture, but they are not wet close enough to the surface or long enough during the growing season to adversely affect yields.

Moderately well drained.—These soils are wet close enough to the surface or long enough that planting or harvesting operations or yields of some field crops are adversely affected unless artificial drainage is provided. Moderately well drained soils commonly have a layer with low hydraulic conductivity, a wet layer relatively high in the profile, additions of water by seepage, or some combination of these.

Somewhat poorly drained.—These soils are wet close enough to the surface or long enough that planting or harvesting operations or crop growth is markedly restricted unless artificial drainage is provided. Somewhat poorly drained soils commonly have a layer with low hydraulic conductivity, a wet

layer high in the profile, additions of water through seepage, or a combination of these.

Poorly drained.—These soils commonly are so wet at or near the surface during a considerable part of the year that field crops cannot be grown under natural conditions. Poorly drained conditions are caused by a saturated zone, a layer with low hydraulic conductivity, seepage, or a combination of these.

Very poorly drained.—These soils are wet to the surface most of the time. They are wet enough to prevent the growth of important crops (except rice) unless artificially drained.

Drainage, surface. Runoff, or surface flow of water, from an area.

Eluviation. The movement of material in true solution or colloidal suspension from one place to another within the soil. Soil horizons that have lost material through eluviation are eluvial; those that have received material are illuvial.

Erosion. The wearing away of the land surface by water, wind, ice, or other geologic agents and by such processes as gravitational creep.

Erosion (geologic). Erosion caused by geologic processes acting over long geologic periods and resulting in the wearing away of mountains and the building up of such landscape features as flood plains and coastal plains. Synonym: natural erosion.

Erosion (accelerated). Erosion much more rapid than geologic erosion, mainly as a result of the activities of man or other animals or of a catastrophe in nature; for example, fire that exposes the surface.

Escarpment. A relatively continuous and steep slope or cliff breaking the general continuity of more gently sloping land surfaces and produced by erosion or faulting. Synonym: scarp.

Excess fines (in tables). Excess silt and clay in the soil. The soil does not provide a source of gravel or sand for construction purposes.

Extrusive rock. Igneous rock derived from deep-seated molten matter (magma) emplaced on the earth's surface.

Fallow. Cropland left idle in order to restore productivity through accumulation of moisture. Summer fallow is common in regions of limited rainfall where cereal grain is grown. The soil is tilled for at least one growing season for weed control and decomposition of plant residue.

Fast intake (in tables). The rapid movement of water into the soil.

Fertility, soil. The quality that enables a soil to provide plant nutrients, in adequate amounts and in proper balance, for the growth of specified plants when light, moisture, temperature, tilth, and other growth factors are favorable.

Fibric soil material (peat). The least decomposed of all organic soil material. Peat contains a large amount of well preserved fiber that is readily identifiable according to botanical origin. Peat has the lowest bulk density and the highest water content at saturation of all organic soil material.

Fine textured soil. Sandy clay, silty clay, and clay.

Firebreak. Area cleared of flammable material to stop or help control creeping or running fires. It also serves as a line from which to work and to facilitate the movement of men and equipment in fire fighting. Designated roads also serve as firebreaks.

Flood plain. A nearly level alluvial plain that borders a stream and is subject to flooding unless protected artificially.

Foraminiferal limestone. Limestone composed chiefly of the remains of bottom dwelling and floating foraminifera (protozoans).

Foot slope. The inclined surface at the base of a hill.

Forb. Any herbaceous plant not a grass or a sedge.

Forest type. A stand of trees similar in composition and development because of given physical and biological factors by which it may be differentiated from other stands.

Genesis, soil. The mode of origin of the soil. Refers especially to the processes or soil-forming factors responsible for the formation of the solum, or true soil, from the unconsolidated parent material.

Gleyed soil. Soil that formed under poor drainage, resulting in the reduction of iron and other elements in the profile and in gray colors and mottles.

Grassed waterway. A natural or constructed waterway, typically broad and shallow, seeded to grass as protection against erosion. Conducts surface water away from cropland.

Gravelly soil material. Material that is 15 to 50 percent, by volume, rounded or angular rock fragments, not prominently flattened, as much as 7.6 centimeters in diameter.

Green manure crop (agronomy). A soil-improving crop grown to be plowed under in an early stage of maturity or soon after maturity.

Ground water (geology). Water filling all the unblocked pores of underlying material below the water table.

Gully. A miniature valley with steep sides cut by running water and through which water ordinarily runs only after rainfall. The distinction between a gully and a rill is one of depth. A gully generally is an obstacle to farm machinery and is too deep to be obliterated by ordinary tillage; a rill is of lesser depth and can be smoothed over by ordinary tillage.

Hard rock. Rock that cannot be excavated except by blasting or by the use of special equipment that is not commonly used in construction.

Hemic soil material (mucky peat). Organic soil material intermediate in degree of decomposition between

the less decomposed fibric material and the more decomposed sapric material.

Horizon, soil. A layer of soil, approximately parallel to the surface, having distinct characteristics produced by soil-forming processes. In the identification of soil horizons, an upper case letter represents the major horizons. Numbers or lower case letters that follow represent subdivisions of the major horizons. An explanation of the subdivisions is given in the *Soil Survey Manual.* The major horizons of mineral soil are as follows:

O horizon.—An organic layer of fresh and decaying plant residue.

A horizon.—The mineral horizon at or near the surface in which an accumulation of humified organic matter is mixed with the mineral material. Also, a plowed surface horizon, most of which was originally part of a B horizon.

B horizon.—The mineral horizon below an A horizon. The B horizon is in part a layer of transition from the overlying A to the underlying C horizon. The B horizon also has distinctive characteristics such as (1) accumulation of clay, sesquioxides, humus, or a combination of these; (2) prismatic or blocky structure; (3) redder or browner colors than those in the A horizon; or (4) a combination of these.

C horizon.—The mineral horizon or layer, excluding indurated bedrock, that is little affected by soil-forming processes and does not have the properties typical of the overlying soil material. The material of a C horizon may be either like or unlike that in which the solum formed. If the material is known to differ from that in the solum, the number 2 precedes the letter C.

R layer.—Consolidated rock beneath the soil. The rock commonly underlies a C horizon, but it can be directly below an A or a B horizon.

Humus. The well decomposed, more or less stable part of the organic matter in mineral soils.

Hydrologic soil groups. Refers to soils grouped according to their runoff-producing characteristics. The chief consideration is the inherent capacity of soil bare of vegetation to permit infiltration. The slope and the kind of plant cover are not considered but are separate factors in predicting runoff. Soils are assigned to four groups. In group A are soils having a high infiltration rate when thoroughly wet and having a low runoff potential. They are mainly deep, well drained, and sandy or gravelly. In group D, at the other extreme, are soils having a very slow infiltration rate and thus a high runoff potential. They have a claypan or clay layer at or near the surface, have a permanent high water table, or are shallow over nearly impervious bedrock or other material. A soil is assigned to two hydrologic groups if part of the acreage is artificially drained and part is undrained.

Igneous rock. Rock formed by solidification from a molten or partially molten state. Major varieties include plutonic and volcanic rock. Examples are andesite, basalt, and granite.

Illuviation. The movement of soil material from one horizon to another in the soil profile. Generally, material is removed from an upper horizon and deposited in a lower horizon.

Infiltration. The downward entry of water into the immediate surface of soil or other material, as contrasted with percolation, which is movement of water through soil layers or material.

Infiltration rate. The rate at which water penetrates the surface of the soil at any given instant, usually expressed in centimeters per hour. The rate can be limited by the infiltration capacity of the soil or the rate at which water is applied at the surface.

Irrigation. Application of water to soils to assist in production of crops. Methods of irrigation are—

Drip (or trickle).—Water is applied slowly and under low pressure to the surface of the soil or into the soil through such applicators as emitters, porous tubing, or perforated pipe.

Karst (topography). The relief of an area underlain by limestone that dissolves in differing degrees, thus forming numerous depressions or small basins.

Leaching. The removal of soluble material from soil or other material by percolating water.

Light textured soil. Sand and loamy sand.

Liquid limit. The moisture content at which the soil passes from a plastic to a liquid state.

Loam. Soil material that is 7 to 27 percent clay particles, 28 to 50 percent silt particles, and less than 52 percent sand particles.

Low strength. The soil is not strong enough to support loads.

Medium textured soil. Very fine sandy loam, loam, silt loam, or silt.

Mineral soil. Soil that is mainly mineral material and low in organic material. Its bulk density is more than that of organic soil.

Miscellaneous area. An area that has little or no natural soil and supports little or no vegetation.

Morphology, soil. The physical makeup of the soil, including the texture, structure, porosity, consistence, color, and other physical, mineral, and biological properties of the various horizons, and the thickness and arrangement of those horizons in the soil profile.

Mottling, soil. Irregular spots of different colors that vary in number and size. Mottling generally indicates poor aeration and impeded drainage. Descriptive terms are as follows: abundance—*few, common,* and *many*; size—*fine, medium,* and *coarse*; and contrast—*faint, distinct,* and *prominent.* The size measurements are of the diameter along the greatest dimension. *Fine* indicates less than 5

millimeters; *medium*, from 5 to 15 millimeters; and *coarse*, more than 15 millimeters.

Muck. Dark colored, finely divided, well decomposed organic soil material. (See Sapric soil material.)

Munsell notation. A designation of color by degrees of the three simple variables—hue, value, and chroma. For example, a notation of 10YR 6/4 is a color in hue of 10YR, value of 6, and chroma of 4.

Neutral soil. A soil having a pH value between 6.6 and 7.3. (See Reaction, soil.)

Nutrient, plant. Any element taken in by a plant essential to its growth. Plant nutrients are mainly nitrogen, phosphorus, potassium, calcium, magnesium, sulfur, iron, manganese, copper, boron, and zinc obtained from the soil and carbon, hydrogen, and oxygen obtained from the air and water.

Organic matter. Plant and animal residue in the soil in various stages of decomposition.

Parent material. The unconsolidated organic and mineral material in which soil forms.

Peat. Unconsolidated material, largely undecomposed organic matter, that has accumulated under excess moisture. (See Fibric soil material.)

Ped. An individual natural soil aggregate, such as a granule, a prism, or a block.

Pedon. The smallest volume that can be called "a soil." A pedon is three dimensional and large enough to permit study of all horizons. Its area ranges from about 1 square meter to 10 square meters, depending on the variability of the soil.

Percolation. The downward movement of water through the soil.

Percs slowly (in tables). The slow movement of water through the soil, adversely affecting the specified use.

Permeability. The quality of the soil that enables water to move downward through the profile. Permeability is measured as the number of centimeters per hour that water moves downward through the saturated soil. Terms describing permeability are:

Very slow	Less than 0.02 centimeter
Slow	0.02 to 0.5 centimeter
Moderately slow	0.5 to 1.5 centimeters
Moderate	1.5 centimeters to 5.0 centimeters
Moderately rapid	5 to 15 centimeters
Rapid	15 to 50 centimeters
Very rapid	More than 50 centimeters

Phase, soil. A subdivision of a soil series based on features that affect its use and management. For example, slope, stoniness, and thickness.

pH value. A numerical designation of acidity and alkalinity in soil. (See Reaction, soil.)

Piping (in tables). Formation of subsurface tunnels or pipelike cavities by water moving through the soil.

Plasticity index. The numerical difference between the liquid limit and the plastic limit; the range of moisture content within which the soil remains plastic.

Plastic limit. The moisture content at which a soil changes from semisolid to plastic.

Plateau. An extensive upland mass with relatively flat summit area that is considerably elevated (more than 100 meters) above adjacent lowlands and separated from them on one or more sides by escarpments.

Plowpan. A compacted layer formed in the soil directly below the plowed layer.

Ponding. Standing water on soils in closed depressions. The water can be removed only by percolation or evapotranspiration.

Poor filter (in tables). Because of rapid permeability or an impermeable layer near the surface, the soil may not adequately filter effluent from a waste disposal system.

Profile, soil. A vertical section of the soil extending through all its horizons and into the parent material.

Rangeland. Land on which the potential natural vegetation is predominantly grasses, grasslike plants, forbs, or shrubs suitable for grazing or browsing. It includes natural grasslands, savannas, many wetlands, some deserts, tundras, and areas that support certain forb and shrub communities.

Reaction, soil. A measure of acidity or alkalinity of a soil, expressed in pH values. A soil that tests to pH 7.0 is described as precisely neutral in reaction because it is neither acid nor alkaline. The degree of acidity or alkalinity is expressed as—

	pH
Extremely acid	Below 4.5
Very strongly acid	4.5 to 5.0
Strongly acid	5.1 to 5.5
Medium acid	5.6 to 6.0
Slightly acid	6.1 to 6.5
Neutral	6.6 to 7.3
Mildly alkaline	7.4 to 7.8
Moderately alkaline	7.9 to 8.4
Strongly alkaline	8.5 to 9.0
Very strongly alkaline	9.1 and higher

Relief. The elevations or inequalities of a land surface, considered collectively.

Residuum (residual soil material). Unconsolidated, weathered, or partly weathered mineral material that accumulated as consolidated rock disintegrated in place.

Road cut. A sloping surface produced by mechanical means during road construction. It is commonly on the uphill side of the road.

Rock fragments. Rock or mineral fragments having a diameter of 2 millimeters or more; for example, pebbles, cobbles, stones, and boulders.

Root zone. The part of the soil that can be penetrated by plant roots.

Rooting depth (in tables). Shallow root zone. The soil is shallow over a layer that greatly restricts roots.

Runoff. The precipitation discharged into stream channels from an area. The water that flows off the

surface of the land without sinking into the soil is called surface runoff. Water that enters the soil before reaching surface streams is called ground-water runoff or seepage flow from ground water.

Sand. As a soil separate, individual rock or mineral fragments from 0.05 millimeter to 2.0 millimeters in diameter. Most sand grains consist of quartz. As a soil textural class, a soil that is 85 percent or more sand and not more than 10 percent clay.

Sandstone. Sedimentary rock containing dominantly sand-size particles.

Sapric soil material (muck). The most highly decomposed of all organic soil material. Muck has the least amount of plant fiber, the highest bulk density, and the lowest water content at saturation of all organic soil material.

Saprolite (soil science). Unconsolidated residual material underlying the soil and grading to hard bedrock below.

Sedimentary rock. Rock made up of particles deposited from suspension in water. The chief kinds of sedimentary rock are conglomerate, formed from gravel; sandstone, formed from sand; shale, formed from clay; and limestone, formed from soft masses of calcium carbonate. There are many intermediate types. Some wind-deposited sand is consolidated into sandstone.

Seepage (in tables). The movement of water through the soil. Seepage adversely affects the specified use.

Series, soil. A group of soils that have profiles that are almost alike, except for differences in texture of the surface layer or of the underlying material. All the soils of a series have horizons that are similar in composition, thickness, and arrangement.

Shale. Sedimentary rock formed by the hardening of a clay deposit.

Sheet erosion. The removal of a fairly uniform layer of soil material from the land surface by the action of rainfall and runoff water.

Shrink-swell (in tables). The shrinking of soil when dry and the swelling when wet. Shrinking and swelling can damage roads, dams, building foundations, and other structures. It can also damage plant roots.

Silica. A combination of silicon and oxygen. The mineral form is called quartz.

Silt. As a soil separate, individual mineral particles that range in diameter from the upper limit of clay (0.002 millimeter) to the lower limit of very fine sand (0.05 millimeter). As a soil textural class, soil that is 80 percent or more silt and less than 12 percent clay.

Slickensides. Polished and grooved surfaces produced by one mass sliding past another. In soils, slickensides may occur at the bases of slip surfaces on the steeper slopes; on faces of blocks, prisms, and columns; and in swelling clayey soils, where there is marked change in moisture content.

Slippage (in tables). Soil mass susceptible to movement downslope when loaded, excavated, or wet.

Slope. The inclination of the land surface from the horizontal. Percentage of slope is the vertical distance divided by horizontal distance, then multiplied by 100. Thus, a slope of 20 percent is a drop of 20 feet in 100 feet of horizontal distance.

Slope (in tables). Slope is great enough that special practices are required to ensure satisfactory performance of the soil for a specific use.

Slow intake (in tables). The slow movement of water into the soil.

Slow refill (in tables). The slow filling of ponds, resulting from restricted permeability in the soil.

Small stones (in tables). Rock fragments less than 3 centimeters (7.5 centimeters) in diameter. Small stones adversely affect the specified use of the soil.

Soil. A natural, three-dimensional body at the earth's surface. It is capable of supporting plants and has properties resulting from the integrated effect of climate and living matter acting on earthy parent material, as conditioned by relief over periods of time.

Soil separates. Mineral particles less than 2 millimeters in equivalent diameter and ranging between specified size limits. The names and sizes of separates recognized in the United States are as follows:

	Millimeters
Very coarse sand	2.0 to 1.0
Coarse sand	1.0 to 0.5
Medium sand	0.5 to 0.25
Fine sand	0.25 to 0.10
Very fine sand	0.10 to 0.05
Silt	0.05 to 0.002
Clay	Less than 0.002

Solum. The upper part of a soil profile, above the C horizon, in which the processes of soil formation are active. The solum in soil consists of the A, E, and B horizons. Generally, the characteristics of the material in these horizons are unlike those of the underlying material. The living roots and plant and animal activities are largely confined to the solum.

Stones. Rock fragments 10 to 24 centimeters (25 to 60 centimeters) in diameter if rounded or 6 to 15 centimeters (15 to 38 centimeters) in length if flat.

Strand. Refers to shore or beach.

Structure, soil. The arrangement of primary soil particles into compound particles or aggregates. The principal forms of soil structure are—*platy* (laminated), *prismatic* (vertical axis of aggregates longer than horizontal), *columnar* (prisms with rounded tops), *blocky* (angular or subangular), and *granular*. *Structureless* soils are either *single grained* (each grain by itself, as in dune sand) or *massive* (the particles adhering without any regular cleavage, as in many hardpans).

Subsoil. Technically, the B horizon; roughly, the part of the solum below plow depth.

Subsoiling. Tilling a soil below normal plow depth, ordinarily to shatter a hardpan or claypan.

Substratum. The part of the soil below the solum.

Subsurface layer. Technically, the E horizon. Generally refers to a leached horizon lighter in color and lower in content of organic matter than the overlying surface layer.

Surface layer. The soil ordinarily moved in tillage, or its equivalent in uncultivated soil, ranging in depth from 4 to 10 centimeters (10 to 25 centimeters). Frequently designated as the "plow layer," or the "Ap horizon."

Terrace. An embankment, or ridge, constructed across sloping soils on the contour or at a slight angle to the contour. The terrace intercepts surface runoff so that water soaks into the soil or flows slowly to a prepared outlet. A terrace in a field generally is built so that the field can be farmed. A terrace intended mainly for drainage has a deep channel that is maintained in permanent sod.

Texture, soil. The relative proportions of sand, silt, and clay particles in a mass of soil. The basic textural classes, in order of increasing proportion of fine particles, are *sand, loamy sand, sandy loam, loam, silt loam, silt, sandy clay loam, clay loam, silty clay loam, sandy clay, silty clay,* and *clay*. The sand, loamy sand, and sandy loam classes may be further divided by specifying "coarse," "fine," or "very fine."

Thin layer (in tables). Otherwise suitable soil material too thin for the specified use.

Toe slope. The outermost inclined surface at the base of a hill; part of a foot slope.

Topsoil. The upper part of the soil, which is the most favorable material for plant growth. It is ordinarily rich in organic matter and is used to topdress roadbanks, lawns, and land affected by mining.

Trace elements. Chemical elements, for example, zinc, cobalt, manganese, copper, and iron, that are in soils in extremely small amounts. They are essential to plant growth.

Tuff. A compacted deposit that is 50 percent or more volcanic ash and dust.

Upland (geology). Land at a higher elevation, in general, than the alluvial plain or stream terrace; land above the lowlands along streams.

Variant, soil. A soil having properties sufficiently different from those of other known soils to justify a new series name, but occurring in such a limited geographic area that creation of a new series is not justified.

Variegation. Refers to patterns of contrasting colors assumed to be inherited from the parent material rather than to be the result of poor drainage.

Weathering. All physical and chemical changes produced in rocks or other deposits at or near the earth's surface by atmospheric agents. These changes result in disintegration and decomposition of the material.

Tables

TABLE 1.--HECTARAGE AND PROPORTIONATE EXTENT OF THE SOILS

Map symbol	Soil name	Hectares	Percent
1	Agfayan clay, 15 to 30 percent slopes	460	0.8
2	Agfayan clay, 30 to 60 percent slopes	192	0.4
3	Agfayan-Rock outcrop complex, 7 to 15 percent slopes	55	0.1
4	Agfayan-Rock outcrop complex, 15 to 30 percent slopes	172	0.3
5	Agfayan-Rock outcrop complex, 30 to 60 percent slopes	560	1.0
6	Agfayan-Akina association, extremely steep	1,556	2.8
7	Agfayan-Akina-Rock outcrop association, extremely steep	3,809	6.9
8	Akina silty clay, 3 to 7 percent slopes	131	0.2
9	Akina silty clay, 7 to 15 percent slopes	646	1.2
10	Akina silty clay, 15 to 30 percent slopes	524	1.0
11	Akina silty clay, 30 to 60 percent slopes	84	0.2
12	Akina-Agfayan association, steep	1,377	2.5
13	Akina-Atate silty clays, 0 to 7 percent slopes	62	0.1
14	Akina-Atate silty clays, 7 to 15 percent slopes	321	0.6
15	Akina-Atate silty clays, 15 to 30 percent slopes	467	0.9
16	Akina-Atate silty clays, 30 to 60 percent slopes	81	0.1
17	Akina-Atate association, steep	985	1.8
18	Akina-Badland complex, 7 to 15 percent slopes	588	1.1
19	Akina-Badland complex, 15 to 30 percent slopes	1,599	2.9
20	Akina-Badland complex, 30 to 60 percent slopes	212	0.4
21	Akina-Badland association, steep	1,278	2.3
22	Akina-Urban land complex, 0 to 7 percent slopes	462	0.8
23	Chacha clay, 0 to 5 percent slopes	331	0.6
24	Chacha Variant clay, 0 to 3 percent slopes	124	0.2
25	Guam cobbly clay loam, 3 to 7 percent slopes	12,261	22.4
26	Guam cobbly clay loam, 7 to 15 percent slopes	901	1.6
27	Guam-Saipan complex, 0 to 7 percent slopes	341	0.6
28	Guam-Urban land complex, 0 to 3 percent slopes	5,811	10.7
29	Guam-Yigo complex, 0 to 7 percent slopes	493	0.9
30	Inarajan clay, 0 to 4 percent slopes	1,595	2.9
31	Inarajan sandy clay loam, 0 to 3 percent slopes	144	0.3
32	Inarajan Variant mucky clay, 0 to 3 percent slopes	160	0.3
33	Pulantat clay, 3 to 7 percent slopes	436	0.8
34	Pulantat clay, 7 to 15 percent slopes	1,011	1.8
35	Pulantat clay, 15 to 30 percent slopes	1,381	2.5
36	Pulantat clay, 30 to 60 percent slopes	1,426	2.6
37	Pulantat-Chacha clays, undulating	106	0.2
38	Pulantat-Chacha clays, rolling	182	0.3
39	Pulantat-Kagman clays, 0 to 7 percent slopes	715	1.3
40	Pulantat-Kagman clays, 7 to 15 percent slopes	82	0.1
41	Pulantat-Urban land complex, 0 to 7 percent slopes	581	1.1
42	Pulantat-Urban land complex, 7 to 15 percent slopes	265	0.5
43	Ritidian-Rock outcrop complex, 3 to 15 percent slopes	2,940	5.4
44	Ritidian-Rock outcrop complex, 15 to 60 percent slopes	3,000	5.5
45	Rock outcrop-Ritidian complex, 60 to 99 percent slopes	541	1.0
46	Sasalaguan clay, 7 to 15 percent slopes	333	0.6
47	Shioya loamy sand, 0 to 5 percent slopes	546	1.0
48	Togcha-Akina silty clays, 3 to 7 percent slopes	460	0.8
49	Togcha-Akina silty clays, 7 to 15 percent slopes	674	1.2
50	Togcha-Ylig complex, 3 to 7 percent slopes	243	0.4
51	Togcha-Ylig complex, 7 to 15 percent slopes	232	0.4
52	Troposaprists, 0 to 1 percent slopes	86	0.2
53	Urban land-Ustorthents complex, nearly level	782	1.4
54	Ylig clay, 0 to 3 percent slopes	286	0.5
55	Ylig clay, 3 to 7 percent slopes	743	1.4
	Water	80	0.1
	Total	54,908	100.0

TABLE 2.--CAPABILITY CLASSES AND SUBCLASSES

[All soils are assigned to nonirrigated capability subclasses (N). Only potentially irrigable soils are assigned to irrigated subclasses (I). Miscellaneous areas are excluded. Absence of an entry indicates no hectarage]

Class	Total hectarage	Major management concerns (Subclass)		
		Erosion (e)	Wetness (w)	Soil problem (s)
		Hectares	Hectares	Hectares
I (N)	473	---	---	---
(I)	---	---	---	---
II (N)	2,970	---	1,576	1,393
(I)	---	---	---	---
III (N)	3,799	2,486	1,313	---
(I)	---	---	---	---
IV (N)	19,865	---	158	19,707
(I)	---	---	---	---
V (N)	---	---	---	---
VI (N)	4,000	4,000	---	---
VII (N)	13,455	10,059	---	3,396
VIII (N)	---	---	---	---

TABLE 3.--WOODLAND MANAGEMENT AND PRODUCTIVITY

[Absence of an entry indicates that information was not available]

Soil name and map symbol	Management concerns: Erosion hazard	Equipment limitation	Seedling mortality	Windthrow hazard	Plant competition	Common trees	Trees to plant
1----------------- Agfayan	Moderate	Moderate	Moderate	Moderate	Severe	---	---
2----------------- Agfayan	Severe	Severe	Moderate	Moderate	Moderate	---	---
3*:							
Agfayan-----------	Slight	Slight	Moderate	Moderate	Severe	---	---
Rock outcrop.							
4*:							
Agfayan-----------	Moderate	Moderate	Moderate	Moderate	Severe	---	---
Rock outcrop.							
5*:							
Agfayan-----------	Severe	Severe	Moderate	Moderate	Moderate	---	---
Rock outcrop.							
6*:							
Agfayan-----------	Severe	Severe	Moderate	Moderate	Moderate	---	---
Akina-------------	Severe	Severe	Slight	Moderate	Severe	---	---
7*:							
Agfayan-----------	Severe	Severe	Moderate	Moderate	Moderate	---	---
Akina-------------	Severe	Severe	Slight	Moderate	Severe	---	---
Rock outcrop.							
8, 9-------------- Akina	Slight	Moderate	Slight	Moderate	Severe	Horsetail casuarina---	---
10---------------- Akina	Moderate	Moderate	Slight	Moderate	Severe	---	---
11---------------- Akina	Severe	Severe	Slight	Moderate	Severe	---	---
12*:							
Akina-------------	Severe	Severe	Slight	Moderate	Severe	---	---
Agfayan-----------	Severe	Severe	Moderate	Moderate	Moderate	---	---
13*, 14*:							
Akina-------------	Slight	Moderate	Slight	Moderate	Severe	Horsetail casuarina---	---
Atate-------------	Slight	Moderate	Slight	Moderate	Severe	Horsetail casuarina--- Alexandrian laurel----	--- ---
15*:							
Akina-------------	Moderate	Moderate	Slight	Moderate	Severe	---	---

See footnote at end of table.

TABLE 3.--WOODLAND MANAGEMENT AND PRODUCTIVITY--Continued

Soil name and map symbol	Management concerns: Erosion hazard	Equipment limitation	Seedling mortality	Windthrow hazard	Plant competition	Common trees	Trees to plant
15*:							
Atate	Moderate	Moderate	Slight	Moderate	Severe	---	Formosa koa.
16*, 17*:							
Akina	Severe	Severe	Slight	Moderate	Severe	---	---
Atate	Severe	Severe	Slight	Moderate	Moderate	---	---
18*:							
Akina	Slight	Moderate	Slight	Moderate	Severe	Horsetail casuarina	---
Badland.							
19*:							
Akina	Moderate	Moderate	Slight	Moderate	Severe	---	---
Badland.							
20*, 21*:							
Akina	Severe	Severe	Slight	Moderate	Severe	---	---
Badland.							
22*:							
Akina	Slight	Moderate	Slight	Moderate	Severe	Horsetail casuarina	---
Urban land.							
25, 26 Guam	Slight	Slight	Slight	Moderate	Severe	---	---
27*:							
Guam	Slight	Slight	Slight	Moderate	Severe	---	---
Saipan	Slight	Moderate	Slight	Moderate	Severe	---	Pterocarpus indicus.
28*:							
Guam	Slight	Slight	Slight	Moderate	Severe	---	---
Urban land.							
29*:							
Guam	Slight	Slight	Slight	Moderate	Severe	---	---
Yigo	Slight	Slight	Slight	Moderate	Severe	---	---
30, 31 Inarajan	Slight	Moderate	Slight	Moderate	Severe	---	Pterocarpus indicus.
32 Inarajan Variant	Slight	Severe	Severe	Moderate	Moderate	Sea hibiscus Nipa palm	--- ---
33, 34 Pulantat	Slight	Slight	Slight	Moderate	Severe	---	Teak, Formosa koa.
35 Pulantat	Moderate	Moderate	Slight	Moderate	Severe	---	Teak, Formosa koa.
36 Pulantat	Severe	Severe	Slight	Moderate	Severe	---	Teak, Formosa koa.

See footnote at end of table.

TABLE 3.--WOODLAND MANAGEMENT AND PRODUCTIVITY--Continued

Soil name and map symbol	Management concerns					Common trees	Trees to plant
	Erosion hazard	Equipment limitation	Seedling mortality	Windthrow hazard	Plant competition		
37*, 38*:							
Pulantat	Slight	Slight	Slight	Moderate	Severe	---	Teak, Formosa koa.
Chacha.							
39*, 40*:							
Pulantat	Slight	Slight	Slight	Moderate	Severe	---	Teak, Formosa koa.
Kagman	Slight	Moderate	Slight	Moderate	Severe	---	Pterocarpus indicus.
41*, 42*:							
Pulantat	Slight	Slight	Slight	Moderate	Severe	---	Teak, Formosa koa.
Urban land.							
43*:							
Ritidian	Slight	Severe	Moderate	Severe	Severe	---	---
Rock outcrop.							
44*:							
Ritidian	Severe	Severe	Moderate	Severe	Severe	---	Honduras mahogany.
Rock outcrop.							
45*:							
Rock outcrop.							
Ritidian	Severe	Severe	Moderate	Severe	Severe	---	Honduras mahogany.
46 Sasalaguan	Slight	Moderate	Slight	Moderate	Severe	Horsetail casuarina	---
47 Shioya	Slight	Slight	Slight	Slight	Moderate	Coconut Alexandrian laurel	Spanish cedar.
48*, 49*:							
Togcha	Slight	Moderate	Slight	Moderate	Severe	---	Formosa koa.
Akina	Slight	Moderate	Slight	Moderate	Severe	Horsetail casuarina	---
50*, 51*:							
Togcha	Slight	Moderate	Slight	Moderate	Severe	---	Formosa koa.
Ylig	Slight	--------	Moderate	Slight	Moderate	---	Pterocarpus indicus.
54, 55 Ylig	Slight	--------	Moderate	Slight	Moderate	---	Pterocarpus indicus.

* See description of the map unit for composition and behavior characteristics of the map unit.

TABLE 4.--WINDBREAKS AND ENVIRONMENTAL PLANTINGS

[The symbol < means less than; > means more than. Absence of an entry indicates that trees generally do not grow to the given height on that soil. Only the soils suited to windbreaks and environmental plantings are listed, except for those that are in map units that include such soils]

Soil name and map symbol	Trees having predicted 20-year average height, in meters, of--		
	5-7.5	8-11	>11
8, 9 Akina	Common mango	Formosa koa	Horsetail casuarina.
13*, 14*: Akina	Common mango	Formosa koa	Horsetail casuarina.
Atate.			
18*: Akina	Common mango	Formosa koa	Horsetail casuarina.
Badland.			
22*: Akina	Common mango	Formosa koa	Horsetail casuarina.
Urban land.			
23 Chacha	Common mango	Formosa koa	Horsetail casuarina.
25, 26 Guam	Common mango	Formosa koa, horsetail casuarina.	---
27*: Guam	Common mango	Formosa koa, horsetail casuarina.	---
Saipan	Common mango	Formosa koa	Horsetail casuarina.
28*: Guam	Common mango	Formosa koa, horsetail casuarina.	---
Urban land.			
29*: Guam	Common mango	Formosa koa, horsetail casuarina.	---
Yigo.			
30, 31 Inarajan	Common mango	Formosa koa	Horsetail casuarina.

See footnote at end of table.

TABLE 4.--WINDBREAKS AND ENVIRONMENTAL PLANTINGS--Continued

Soil name and map symbol	Trees having predicted 20-year average height, in meters, of--		
	5-7.5	8-11	>11
33, 34-----------Pulantat	Common mango------	Formosa koa, horsetail casuarina.	---
37*, 38*:			
Pulantat---------	Common mango------	Formosa koa, horsetail casuarina.	---
Chacha-----------	Common mango------	Formosa koa-------	Horsetail casuarina.
39*, 40*:			
Pulantat---------	Common mango------	Formosa koa, horsetail casuarina.	---
Kagman-----------	Common mango------	Formosa koa-------	Horsetail casuarina.
41*, 42*:			
Pulantat---------	Common mango------	Formosa koa, horsetail casuarina.	---
Urban land.			
46---------------Sasalaguan	Common mango------	---	Horsetail casuarina.
47---------------Shioya	Common mango------	Formosa koa-------	Horsetail casuarina.
48*, 49*:			
Togcha-----------	Common mango------	Formosa koa-------	Horsetail casuarina.
Akina------------	Common mango------	Formosa koa-------	Horsetail casuarina.
50*, 51*:			
Togcha-----------	Common mango------	Formosa koa-------	Horsetail casuarina.
Ylig.			

* See description of the map unit for composition and behavior characteristics of the map unit.

TABLE 5.--RECREATIONAL DEVELOPMENT

[Some terms that describe restrictive soil features are defined in the Glossary. See text for definitions of "slight," "moderate," and "severe." Absence of an entry indicates that the soil was not rated]

Soil name and map symbol	Camp areas	Picnic areas	Playgrounds	Paths and trails	Golf fairways
1 Agfayan	Severe: slope, depth to rock.	Severe: slope, depth to rock.	Severe: slope, depth to rock.	Moderate: too clayey, slope.	Severe: slope, depth to rock, too clayey.
2 Agfayan	Severe: slope, depth to rock.	Severe: slope, depth to rock.	Severe: slope, depth to rock.	Severe: slope.	Severe: slope, depth to rock, too clayey.
3*:					
Agfayan	Severe: depth to rock.	Severe: depth to rock.	Severe: slope, depth to rock.	Moderate: too clayey.	Severe: depth to rock, too clayey.
Rock outcrop.					
4*:					
Agfayan	Severe: slope, depth to rock.	Severe: slope, depth to rock.	Severe: slope, depth to rock.	Moderate: too clayey, slope.	Severe: slope, depth to rock, too clayey.
Rock outcrop.					
5*:					
Agfayan	Severe: slope, depth to rock.	Severe: slope, depth to rock.	Severe: slope, depth to rock.	Severe: slope.	Severe: slope, depth to rock, too clayey.
Rock outcrop.					
6*:					
Agfayan	Severe: slope, depth to rock.	Severe: slope, depth to rock.	Severe: slope, depth to rock.	Severe: slope.	Severe: slope, depth to rock, too clayey.
Akina	Severe: slope, too clayey.	Severe: slope, too clayey.	Severe: slope, too clayey.	Severe: too clayey, slope.	Severe: slope, too clayey.
7*:					
Agfayan	Severe: slope, depth to rock.	Severe: slope, depth to rock.	Severe: slope, depth to rock.	Severe: slope.	Severe: slope, depth to rock, too clayey.
Akina	Severe: slope, too clayey.	Severe: slope, too clayey.	Severe: slope, too clayey.	Severe: too clayey, slope.	Severe: slope, too clayey.
Rock outcrop.					
8 Akina	Severe: too clayey.	Severe: too clayey.	Severe: too clayey.	Severe: too clayey.	Severe: too clayey.

See footnote at end of table.

TABLE 5.--RECREATIONAL DEVELOPMENT--Continued

Soil name and map symbol	Camp areas	Picnic areas	Playgrounds	Paths and trails	Golf fairways
9----------------- Akina	Severe: too clayey.	Severe: too clayey.	Severe: slope, too clayey.	Severe: too clayey.	Severe: too clayey.
10----------------- Akina	Severe: slope, too clayey.	Severe: slope, too clayey.	Severe: slope, too clayey.	Severe: too clayey.	Severe: slope, too clayey.
11----------------- Akina	Severe: slope, too clayey.	Severe: slope, too clayey.	Severe: slope, too clayey.	Severe: too clayey, slope.	Severe: slope, too clayey.
12*:					
Akina----------------	Severe: slope, too clayey.	Severe: slope, too clayey.	Severe: slope, too clayey.	Severe: too clayey, slope.	Severe: slope, too clayey.
Agfayan--------------	Severe: slope, depth to rock.	Severe: slope, depth to rock.	Severe: slope, depth to rock.	Severe: slope.	Severe: slope, depth to rock, too clayey.
13*:					
Akina----------------	Severe: too clayey.	Severe: too clayey.	Severe: too clayey.	Severe: too clayey.	Severe: too clayey.
Atate----------------	Severe: too clayey.	Severe: too clayey.	Severe: too clayey.	Severe: too clayey.	Severe: too clayey.
14*:					
Akina----------------	Severe: too clayey.	Severe: too clayey.	Severe: slope, too clayey.	Severe: too clayey.	Severe: too clayey.
Atate----------------	Severe: too clayey.	Severe: too clayey.	Severe: slope, too clayey.	Severe: too clayey.	Severe: too clayey.
15*:					
Akina----------------	Severe: slope, too clayey.	Severe: slope, too clayey.	Severe: slope, too clayey.	Severe: too clayey.	Severe: slope, too clayey.
Atate----------------	Severe: slope, too clayey.	Severe: slope, too clayey.	Severe: slope, too clayey.	Severe: too clayey.	Severe: slope, too clayey.
16*, 17*:					
Akina----------------	Severe: slope, too clayey.	Severe: slope, too clayey.	Severe: slope, too clayey.	Severe: too clayey, slope.	Severe: slope, too clayey.
Atate----------------	Severe: slope, too clayey.	Severe: slope, too clayey.	Severe: slope, too clayey.	Severe: too clayey, slope.	Severe: slope, too clayey.
18*:					
Akina----------------	Severe: too clayey.	Severe: too clayey.	Severe: slope, too clayey.	Severe: too clayey.	Severe: too clayey.

See footnote at end of table.

TABLE 5.--RECREATIONAL DEVELOPMENT--Continued

Soil name and map symbol	Camp areas	Picnic areas	Playgrounds	Paths and trails	Golf fairways
18*: Badland.					
19*: Akina	Severe: slope, too clayey.	Severe: slope, too clayey.	Severe: slope, too clayey.	Severe: too clayey.	Severe: slope, too clayey.
Badland.					
20*, 21*: Akina	Severe: slope, too clayey.	Severe: slope, too clayey.	Severe: slope, too clayey.	Severe: too clayey, slope.	Severe: slope, too clayey.
Badland.					
22*: Akina	Severe: too clayey.	Severe: too clayey.	Severe: too clayey.	Severe: too clayey.	Severe: too clayey.
Urban land.					
23 Chacha	Moderate: wetness, too clayey.	Moderate: wetness, too clayey.	Moderate: slope, too clayey, wetness.	Moderate: wetness, too clayey.	Moderate: wetness, too clayey.
24 Chacha Variant	Severe: wetness, too clayey.	Severe: wetness, too clayey.	Severe: too clayey, wetness.	Severe: wetness, too clayey.	Severe: wetness, too clayey.
25 Guam	Severe: depth to rock.	Severe: depth to rock.	Severe: small stones, depth to rock.	Slight	Severe: thin layer.
26 Guam	Severe: depth to rock.	Severe: depth to rock.	Severe: slope, small stones, depth to rock.	Slight	Severe: thin layer.
27*: Guam	Severe: depth to rock.	Severe: depth to rock.	Severe: small stones, depth to rock.	Slight	Severe: thin layer.
Saipan	Moderate: too clayey.	Moderate: too clayey.	Moderate: small stones, too clayey.	Moderate: too clayey.	Moderate: droughty, too clayey.
28*: Guam	Severe: depth to rock.	Severe: depth to rock.	Severe: small stones, depth to rock.	Slight	Severe: thin layer.
Urban land.					
29*: Guam	Severe: depth to rock.	Severe: depth to rock.	Severe: small stones, depth to rock.	Slight	Severe: thin layer.

See footnote at end of table.

TABLE 5.--RECREATIONAL DEVELOPMENT--Continued

Soil name and map symbol	Camp areas	Picnic areas	Playgrounds	Paths and trails	Golf fairways
29*:					
Yigo	Moderate: too clayey.	Moderate: too clayey.	Moderate: too clayey.	Moderate: too clayey.	Severe: too clayey.
30 Inarajan	Severe: flooding, too clayey.	Severe: too clayey.	Severe: too clayey.	Severe: too clayey.	Severe: too clayey.
31 Inarajan	Severe: flooding.	Moderate: wetness, percs slowly.	Moderate: wetness, flooding.	Moderate: wetness.	Moderate: wetness, flooding.
32 Inarajan Variant	Severe: flooding, wetness, too clayey.	Severe: wetness, too clayey, excess humus.	Severe: too clayey, excess humus, wetness.	Severe: wetness, too clayey, excess humus.	Severe: wetness, flooding, too clayey.
33 Pulantat	Severe: depth to rock.	Severe: depth to rock.	Severe: depth to rock.	Moderate: too clayey.	Severe: depth to rock, too clayey.
34 Pulantat	Severe: depth to rock.	Severe: depth to rock.	Severe: slope, depth to rock.	Moderate: too clayey.	Severe: depth to rock, too clayey.
35 Pulantat	Severe: slope, depth to rock.	Severe: slope, depth to rock.	Severe: slope, depth to rock.	Moderate: too clayey, slope.	Severe: slope, depth to rock, too clayey.
36 Pulantat	Severe: slope, depth to rock.	Severe: slope, depth to rock.	Severe: slope, depth to rock.	Severe: slope.	Severe: slope, depth to rock, too clayey.
37*:					
Pulantat	Severe: depth to rock.	Severe: depth to rock.	Severe: depth to rock.	Moderate: too clayey.	Severe: depth to rock, too clayey.
Chacha	Moderate: wetness, too clayey.	Moderate: wetness, too clayey.	Moderate: slope, too clayey, wetness.	Moderate: wetness, too clayey.	Moderate: wetness, too clayey.
38*:					
Pulantat	Severe: depth to rock.	Severe: depth to rock.	Severe: slope, depth to rock.	Moderate: too clayey.	Severe: depth to rock, too clayey.
Chacha	Moderate: wetness, too clayey.	Moderate: wetness, too clayey.	Moderate: slope, too clayey, wetness.	Moderate: wetness, too clayey.	Moderate: wetness, too clayey.
39*:					
Pulantat	Severe: depth to rock.	Severe: depth to rock.	Severe: depth to rock.	Moderate: too clayey.	Severe: depth to rock, too clayey.
Kagman	Severe: too clayey.	Severe: too clayey.	Severe: too clayey.	Severe: too clayey.	Severe: too clayey.

See footnote at end of table.

TABLE 5.--RECREATIONAL DEVELOPMENT--Continued

Soil name and map symbol	Camp areas	Picnic areas	Playgrounds	Paths and trails	Golf fairways
40*:					
Pulantat	Severe: depth to rock.	Severe: depth to rock.	Severe: slope, depth to rock.	Moderate: too clayey.	Severe: depth to rock, too clayey.
Kagman	Severe: too clayey.	Severe: too clayey.	Severe: slope, too clayey.	Severe: too clayey.	Severe: too clayey.
41*:					
Pulantat	Severe: depth to rock.	Severe: depth to rock.	Severe: depth to rock.	Moderate: too clayey.	Severe: depth to rock, too clayey.
Urban land.					
42*:					
Pulantat	Severe: depth to rock.	Severe: depth to rock.	Severe: slope, depth to rock.	Moderate: too clayey.	Severe: depth to rock, too clayey.
Urban land.					
43*:					
Ritidian	Severe: large stones, small stones.	Severe: large stones, small stones.	Severe: large stones, slope, small stones.	Severe: large stones.	Severe: small stones, large stones.
Rock outcrop.					
44*:					
Ritidian	Severe: slope, large stones, small stones.	Severe: slope, large stones, small stones.	Severe: large stones, slope, small stones.	Severe: large stones, slope.	Severe: small stones, large stones, slope.
Rock outcrop.					
45*:					
Rock outcrop.					
Ritidian	Severe: slope, large stones, small stones.	Severe: slope, large stones, small stones.	Severe: large stones, slope, small stones.	Severe: large stones, slope.	Severe: small stones, large stones, slope.
46 Sasalaguan	Moderate: slope, too clayey.	Moderate: slope, too clayey.	Severe: slope.	Moderate: too clayey.	Severe: too clayey.
47 Shioya	Severe: flooding, excess salt.	Severe: excess salt.	Severe: excess salt.	Slight	Severe: excess salt.
48*:					
Togcha	Severe: too clayey.	Severe: too clayey.	Severe: slope, too clayey.	Severe: too clayey.	Severe: too clayey.
Akina	Severe: too clayey.	Severe: too clayey.	Severe: too clayey.	Severe: too clayey.	Severe: too clayey.

See footnote at end of table.

TABLE 5.--RECREATIONAL DEVELOPMENT--Continued

Soil name and map symbol	Camp areas	Picnic areas	Playgrounds	Paths and trails	Golf fairways
49*:					
Togcha	Severe: too clayey.	Severe: too clayey.	Severe: slope, too clayey.	Severe: too clayey.	Severe: too clayey.
Akina	Severe: too clayey.	Severe: too clayey.	Severe: slope, too clayey.	Severe: too clayey.	Severe: too clayey.
50*:					
Togcha	Severe: too clayey.	Severe: too clayey.	Severe: slope, too clayey.	Severe: too clayey.	Severe: too clayey.
Ylig	Severe: too clayey.	Severe: too clayey.	Severe: too clayey.	Severe: too clayey.	Severe: too clayey.
51*:					
Togcha	Severe: too clayey.	Severe: too clayey.	Severe: slope, too clayey.	Severe: too clayey.	Severe: too clayey.
Ylig	Severe: too clayey.	Severe: too clayey.	Severe: slope, too clayey.	Severe: too clayey.	Severe: too clayey.
52. Troposaprists					
53*: Urban land.					
Ustorthents.					
54, 55 Ylig	Severe: too clayey.	Severe: too clayey.	Severe: too clayey.	Severe: too clayey.	Severe: too clayey.

* See description of the map unit for composition and behavior characteristics of the map unit.

TABLE 6.--WILDLIFE HABITAT POTENTIALS

[See text for definitions of "good," "fair," "poor," and "very poor." Absence of an entry indicates that the soil was not rated]

Soil name and map symbol	Potential for habitat elements					Potential as habitat for--		
	Wild herbaceous plants	Hardwood trees	Shrubs	Wetland plants	Shallow water areas	Openland wildlife	Woodland wildlife	Wetland wildlife
1, 2 Agfayan	Good	Poor	Good	Very poor.	Very poor.	Good	Poor	Very poor.
3*, 4*, 5*:								
Agfayan	Good	Poor	Good	Very poor.	Very poor.	Good	Poor	Very poor.
Rock outcrop.								
6*:								
Agfayan	Good	Poor	Good	Very poor.	Very poor.	Good	Poor	Very poor.
Akina	Good	Fair	Good	Very poor.	Very poor.	Good	Fair	Very poor.
7*:								
Agfayan	Good	Poor	Good	Very poor.	Very poor.	Good	Poor	Very poor.
Akina	Good	Fair	Good	Very poor.	Very poor.	Good	Fair	Very poor.
Rock outcrop.								
8, 9, 10, 11 Akina	Good	Fair	Good	Very poor.	Very poor.	Good	Fair	Very poor.
12*:								
Akina	Good	Fair	Good	Very poor.	Very poor.	Good	Fair	Very poor.
Agfayan	Good	Poor	Good	Very poor.	Very poor.	Good	Poor	Very poor.
13*, 14*, 15*, 16*, 17*:								
Akina	Good	Fair	Good	Very poor.	Very poor.	Good	Fair	Very poor.
Atate	Good	Good	Good	Very poor.	Very poor.	Good	Good	Very poor.
18*, 19*, 20*, 21*:								
Akina	Good	Fair	Good	Very poor.	Very poor.	Good	Fair	Very poor.
Badland.								
22*:								
Akina	Good	Fair	Good	Very poor.	Very poor.	Good	Fair	Very poor.
Urban land.								

See footnote at end of table.

TABLE 6.--WILDLIFE HABITAT POTENTIALS--Continued

Soil name and map symbol	Potential for habitat elements: Wild herbaceous plants	Hardwood trees	Shrubs	Wetland plants	Shallow water areas	Potential as habitat for--: Openland wildlife	Woodland wildlife	Wetland wildlife
23: Chacha	Good	Good	Good	Poor	Poor	Good	Good	Poor.
24: Chacha Variant	Poor	Poor	Poor	Good	Good	Poor	Poor	Good.
25, 26: Guam	Good	Good	Good	Very poor.	Very poor.	Good	Good	Very poor.
27*:								
Guam	Good	Good	Good	Very poor.	Very poor.	Good	Good	Very poor.
Saipan	Good	Good	Good	Very poor.	Very poor.	Good	Good	Very poor.
28*:								
Guam	Good	Good	Good	Very poor.	Very poor.	Good	Good	Very poor.
Urban land.								
29*:								
Guam	Good	Good	Good	Very poor.	Very poor.	Good	Good	Very poor.
Yigo	Fair	Good	Good	Very poor.	Very poor.	Fair	Good	Very poor.
30, 31: Inarajan	Good	Good	Fair	Good	Good	Good	Good	Good.
32: Inarajan Variant	Very poor.	Poor	Poor	Good	Good	Poor	Poor	Good.
33, 34, 35, 36: Pulantat	Good	Good	Good	Very poor.	Very poor.	Good	Good	Very poor.
37*, 38*:								
Pulantat	Good	Good	Good	Very poor.	Very poor.	Good	Good	Very poor.
Chacha	Good	Good	Good	Poor	Poor	Good	Good	Poor.
39*, 40*:								
Pulantat	Good	Good	Good	Very poor.	Very poor.	Good	Good	Very poor.
Kagman	Good	Good	Good	Very poor.	Very poor.	Good	Good	Very poor.
41*, 42*:								
Pulantat	Good	Good	Good	Very poor.	Very poor.	Good	Good	Very poor.
Urban land.								
43*, 44*:								
Ritidian	Fair	Good	Fair	Very poor.	Very poor.	Very poor.	Good	Very poor.

See footnote at end of table.

TABLE 6.--WILDLIFE HABITAT POTENTIALS--Continued

Soil name and map symbol	Potential for habitat elements: Wild herbaceous plants	Hardwood trees	Shrubs	Wetland plants	Shallow water areas	Potential as habitat for--: Openland wildlife	Woodland wildlife	Wetland wildlife
43*, 44*:								
Rock outcrop.								
45*:								
Rock outcrop.								
Ritidian	Fair	Good	Fair	Very poor.	Very poor.	Very poor.	Good	Very poor.
46 Sasalaguan	Good	Poor	Good	Very poor.	Very poor.	Good	Poor	Very poor.
47 Shioya	Poor	Good	Fair	Very poor.	Very poor.	Poor	Good	Very poor.
48*, 49*:								
Togcha	Good	Poor	Good	Very poor.	Poor	Good	Poor	Very poor.
Akina	Good	Fair	Good	Very poor.	Very poor.	Good	Fair	Very poor.
50*, 51*:								
Togcha	Good	Poor	Good	Very poor.	Poor	Good	Poor	Very poor.
Ylig	Good	Good	Fair	Good	Good	Good	Good	Good.
52. Troposaprists								
53*:								
Urban land.								
Ustorthents.								
54, 55 Ylig	Good	Good	Fair	Good	Good	Good	Good	Good.

* See description of the map unit for composition and behavior characteristics of the map unit.

TABLE 7.--BUILDING SITE DEVELOPMENT

[Some terms that describe restrictive soil features are defined in the Glossary. See text for definitions of "slight," "moderate," and "severe." Absence of an entry indicates that the soil was not rated. The information in this table indicates the dominant soil condition but does not eliminate the need for onsite investigation]

Soil name and map symbol	Shallow excavations	Dwellings without basements	Small commercial buildings	Local roads and streets	Lawns and landscaping
1, 2 Agfayan	Severe: depth to rock, slope.	Severe: slope.	Severe: slope.	Severe: slope.	Severe: slope, depth to rock, too clayey.
3*:					
Agfayan	Severe: depth to rock.	Moderate: slope, depth to rock.	Severe: slope.	Moderate: depth to rock, slope.	Severe: depth to rock, too clayey.
Rock outcrop.					
4*, 5*:					
Agfayan	Severe: depth to rock, slope.	Severe: slope.	Severe: slope.	Severe: slope.	Severe: slope, depth to rock, too clayey.
Rock outcrop.					
6*:					
Agfayan	Severe: depth to rock, slope.	Severe: slope.	Severe: slope.	Severe: slope.	Severe: slope, depth to rock, too clayey.
Akina	Severe: slope.	Severe: slope.	Severe: slope.	Severe: low strength, slope.	Severe: slope, too clayey.
7*:					
Agfayan	Severe: depth to rock, slope.	Severe: slope.	Severe: slope.	Severe: slope.	Severe: slope, depth to rock, too clayey.
Akina	Severe: slope.	Severe: slope.	Severe: slope.	Severe: low strength, slope.	Severe: slope, too clayey.
Rock outcrop.					
8 Akina	Slight	Slight	Moderate: slope.	Severe: low strength.	Severe: too clayey.
9 Akina	Moderate: slope.	Moderate: slope.	Severe: slope.	Severe: low strength.	Severe: too clayey.
10, 11 Akina	Severe: slope.	Severe: slope.	Severe: slope.	Severe: low strength, slope.	Severe: slope, too clayey.
12*:					
Akina	Severe: slope.	Severe: slope.	Severe: slope.	Severe: low strength, slope.	Severe: slope, too clayey.

See footnote at end of table.

TABLE 7.--BUILDING SITE DEVELOPMENT--Continued

Soil name and map symbol	Shallow excavations	Dwellings without basements	Small commercial buildings	Local roads and streets	Lawns and landscaping
12*:					
Agfayan	Severe: depth to rock, slope.	Severe: slope.	Severe: slope.	Severe: slope.	Severe: slope, depth to rock, too clayey.
13*:					
Akina	Slight	Slight	Slight	Severe: low strength.	Severe: too clayey.
Atate	Moderate: too clayey.	Moderate: shrink-swell.	Moderate: shrink-swell.	Severe: low strength.	Severe: too clayey.
14*:					
Akina	Moderate: slope.	Moderate: slope.	Severe: slope.	Severe: low strength.	Severe: too clayey.
Atate	Moderate: too clayey, slope.	Moderate: shrink-swell, slope.	Severe: slope.	Severe: low strength.	Severe: too clayey.
15*, 16*, 17*:					
Akina	Severe: slope.	Severe: slope.	Severe: slope.	Severe: low strength, slope.	Severe: slope, too clayey.
Atate	Severe: slope.	Severe: slope.	Severe: slope.	Severe: low strength, slope.	Severe: slope, too clayey.
18*:					
Akina	Moderate: slope.	Moderate: slope.	Severe: slope.	Severe: low strength.	Severe: too clayey.
Badland.					
19*, 20*, 21*:					
Akina	Severe: slope.	Severe: slope.	Severe: slope.	Severe: low strength, slope.	Severe: slope, too clayey.
Badland.					
22*:					
Akina	Slight	Slight	Slight	Severe: low strength.	Severe: too clayey.
Urban land.					
23 Chacha	Severe: wetness.	Severe: shrink-swell.	Severe: shrink-swell.	Severe: shrink-swell.	Moderate: wetness, too clayey.
24 Chacha Variant	Severe: wetness.	Severe: wetness.	Severe: wetness.	Severe: low strength, wetness.	Severe: wetness, too clayey.
25 Guam	Severe: depth to rock.	Severe: depth to rock.	Severe: depth to rock.	Severe: depth to rock.	Severe: thin layer.
26 Guam	Severe: depth to rock.	Severe: depth to rock.	Severe: slope, depth to rock.	Severe: depth to rock.	Severe: thin layer.

See footnote at end of table.

TABLE 7.--BUILDING SITE DEVELOPMENT--Continued

Soil name and map symbol	Shallow excavations	Dwellings without basements	Small commercial buildings	Local roads and streets	Lawns and landscaping
27*:					
Guam	Severe: depth to rock.	Severe: depth to rock.	Severe: depth to rock.	Severe: depth to rock.	Severe: thin layer.
Saipan	Moderate: too clayey.	Moderate: shrink-swell.	Moderate: shrink-swell.	Moderate: shrink-swell, low strength.	Moderate: droughty, too clayey.
28*:					
Guam	Severe: depth to rock.	Severe: depth to rock.	Severe: depth to rock.	Severe: depth to rock.	Severe: thin layer.
Urban land.					
29*:					
Guam	Severe: depth to rock.	Severe: depth to rock.	Severe: depth to rock.	Severe: depth to rock.	Severe: thin layer.
Yigo	Moderate: depth to rock, too clayey.	Slight	Slight	Severe: low strength.	Severe: too clayey.
30 Inarajan	Severe: wetness.	Severe: flooding.	Severe: flooding.	Severe: low strength, flooding.	Severe: too clayey.
31 Inarajan	Severe: cutbanks cave, wetness.	Severe: flooding.	Severe: flooding.	Severe: low strength, flooding.	Moderate: wetness, flooding.
32 Inarajan Variant	Severe: excess humus, wetness.	Severe: flooding, wetness, shrink-swell.	Severe: flooding, wetness, shrink-swell.	Severe: low strength, wetness, flooding.	Severe: wetness, flooding, too clayey.
33 Pulantat	Severe: depth to rock.	Severe: shrink-swell, depth to rock.	Severe: shrink-swell, depth to rock.	Severe: depth to rock, shrink-swell, low strength.	Severe: depth to rock, too clayey.
34 Pulantat	Severe: depth to rock.	Severe: shrink-swell, depth to rock.	Severe: shrink-swell, slope, depth to rock.	Severe: depth to rock, shrink-swell, low strength.	Severe: depth to rock, too clayey.
35, 36 Pulantat	Severe: depth to rock, slope.	Severe: shrink-swell, slope, depth to rock.	Severe: shrink-swell, slope, depth to rock.	Severe: depth to rock, shrink-swell, low strength.	Severe: slope, depth to rock, too clayey.
37*:					
Pulantat	Severe: depth to rock.	Severe: shrink-swell, depth to rock.	Severe: shrink-swell, depth to rock.	Severe: depth to rock, shrink-swell, low strength.	Severe: depth to rock, too clayey.
Chacha	Severe: wetness.	Severe: shrink-swell.	Severe: shrink-swell.	Severe: shrink-swell.	Moderate: wetness, too clayey.
38*:					
Pulantat	Severe: depth to rock.	Severe: shrink-swell, depth to rock.	Severe: shrink-swell, slope, depth to rock.	Severe: depth to rock, shrink-swell, low strength.	Severe: depth to rock, too clayey.

See footnote at end of table.

TABLE 7.--BUILDING SITE DEVELOPMENT--Continued

Soil name and map symbol	Shallow excavations	Dwellings without basements	Small commercial buildings	Local roads and streets	Lawns and landscaping
38*:					
Chacha	Severe: wetness.	Severe: shrink-swell.	Severe: shrink-swell.	Severe: shrink-swell.	Moderate: wetness, too clayey.
39*:					
Pulantat	Severe: depth to rock.	Severe: shrink-swell, depth to rock.	Severe: shrink-swell, depth to rock.	Severe: depth to rock, shrink-swell, low strength.	Severe: depth to rock, too clayey.
Kagman	Moderate: too clayey.	Severe: shrink-swell.	Severe: shrink-swell.	Severe: shrink-swell, low strength.	Severe: too clayey.
40*:					
Pulantat	Severe: depth to rock.	Severe: shrink-swell, depth to rock.	Severe: shrink-swell, slope, depth to rock.	Severe: depth to rock, shrink-swell, low strength.	Severe: depth to rock, too clayey.
Kagman	Moderate: too clayey, slope.	Severe: shrink-swell.	Severe: shrink-swell, slope.	Severe: shrink-swell, low strength.	Severe: too clayey.
41*:					
Pulantat	Severe: depth to rock.	Severe: shrink-swell, depth to rock.	Severe: shrink-swell, depth to rock.	Severe: depth to rock, shrink-swell, low strength.	Severe: depth to rock, too clayey.
Urban land.					
42*:					
Pulantat	Severe: depth to rock.	Severe: shrink-swell, depth to rock.	Severe: shrink-swell, slope, depth to rock.	Severe: depth to rock, shrink-swell, low strength.	Severe: depth to rock, too clayey.
Urban land.					
43*:					
Ritidian	Severe: depth to rock, large stones.	Severe: large stones.	Severe: slope, large stones.	Severe: large stones.	Severe: small stones, large stones.
Rock outcrop.					
44*:					
Ritidian	Severe: depth to rock, large stones, slope.	Severe: slope, large stones.	Severe: slope, large stones.	Severe: slope, large stones.	Severe: small stones, large stones, slope.
Rock outcrop.					
45*:					
Rock outcrop.					
Ritidian	Severe: depth to rock, large stones, slope.	Severe: slope, large stones.	Severe: slope, large stones.	Severe: slope, large stones.	Severe: small stones, large stones, slope.

See footnote at end of table.

TABLE 7.--BUILDING SITE DEVELOPMENT--Continued

Soil name and map symbol	Shallow excavations	Dwellings without basements	Small commercial buildings	Local roads and streets	Lawns and landscaping
46----------------- Sasalaguan	Moderate: depth to rock, too clayey, slope.	Severe: shrink-swell.	Severe: shrink-swell, slope.	Severe: shrink-swell, low strength.	Severe: too clayey.
47----------------- Shioya	Severe: cutbanks cave.	Severe: flooding.	Severe: flooding.	Moderate: flooding.	Severe: excess salt.
48*:					
Togcha-----------	Moderate: too clayey.	Moderate: shrink-swell.	Moderate: shrink-swell, slope.	Severe: low strength.	Severe: too clayey.
Akina------------	Slight-----------	Slight-----------	Moderate: slope.	Severe: low strength.	Severe: too clayey.
49*:					
Togcha-----------	Moderate: slope.	Moderate: shrink-swell, slope.	Severe: slope.	Severe: low strength.	Severe: too clayey.
Akina------------	Moderate: slope.	Moderate: slope.	Severe: slope.	Severe: low strength.	Severe: too clayey.
50*:					
Togcha-----------	Moderate: too clayey.	Moderate: shrink-swell.	Moderate: shrink-swell.	Severe: low strength.	Severe: too clayey.
Ylig-------------	Severe: wetness.	Moderate: wetness, shrink-swell.	Moderate: wetness, shrink-swell, slope.	Severe: low strength.	Severe: too clayey.
51*:					
Togcha-----------	Moderate: slope.	Moderate: shrink-swell, slope.	Severe: slope.	Severe: low strength.	Severe: too clayey.
Ylig-------------	Severe: wetness.	Moderate: wetness, shrink-swell, slope.	Severe: slope.	Severe: low strength.	Severe: too clayey.
52. Troposaprists					
53*: Urban land.					
Ustorthents.					
54----------------- Ylig	Severe: wetness.	Moderate: wetness, shrink-swell.	Moderate: wetness, shrink-swell.	Severe: low strength.	Severe: too clayey.
55----------------- Ylig	Severe: wetness.	Moderate: wetness, shrink-swell.	Moderate: wetness, shrink-swell, slope.	Severe: low strength.	Severe: too clayey.

* See description of the map unit for composition and behavior characteristics of the map unit.

TABLE 8.--SANITARY FACILITIES

[Some terms that describe restrictive soil features are defined in the Glossary. See text for definitions of "slight," "good," and other terms. Absence of an entry indicates that the soil was not rated. The information in this table indicates the dominant soil condition but does not eliminate the need for onsite investigation]

Soil name and map symbol	Septic tank absorption fields	Sewage lagoon areas	Trench sanitary landfill	Area sanitary landfill	Daily cover for landfill
1, 2---------------- Agfayan	Severe: depth to rock, slope.	Severe: depth to rock, slope.	Severe: depth to rock, slope.	Severe: depth to rock, slope.	Poor: depth to rock, slope.
3*:					
Agfayan------------	Severe: depth to rock.	Severe: depth to rock, slope.	Severe: depth to rock.	Severe: depth to rock.	Poor: depth to rock.
Rock outcrop.					
4*, 5*:					
Agfayan------------	Severe: depth to rock, slope.	Severe: depth to rock, slope.	Severe: depth to rock, slope.	Severe: depth to rock, slope.	Poor: depth to rock, slope.
Rock outcrop.					
6*:					
Agfayan------------	Severe: depth to rock, slope.	Severe: depth to rock, slope.	Severe: depth to rock, slope.	Severe: depth to rock, slope.	Poor: depth to rock, slope.
Akina--------------	Severe: percs slowly, slope.	Severe: slope.	Severe: slope.	Severe: slope.	Poor: slope.
7*:					
Agfayan------------	Severe: depth to rock, slope.	Severe: depth to rock, slope.	Severe: depth to rock, slope.	Severe: depth to rock, slope.	Poor: depth to rock, slope.
Akina--------------	Severe: percs slowly, slope.	Severe: slope.	Severe: slope.	Severe: slope.	Poor: slope.
Rock outcrop.					
8------------------- Akina	Severe: percs slowly.	Moderate: seepage, slope.	Moderate: too clayey.	Slight-----------	Fair: too clayey.
9------------------- Akina	Severe: percs slowly.	Severe: slope.	Moderate: slope, too clayey.	Moderate: slope.	Fair: too clayey, slope.
10, 11-------------- Akina	Severe: percs slowly, slope.	Severe: slope.	Severe: slope.	Severe: slope.	Poor: slope.
12*:					
Akina--------------	Severe: percs slowly, slope.	Severe: slope.	Severe: slope.	Severe: slope.	Poor: slope.

See footnote at end of table.

TABLE 8.--SANITARY FACILITIES--Continued

Soil name and map symbol	Septic tank absorption fields	Sewage lagoon areas	Trench sanitary landfill	Area sanitary landfill	Daily cover for landfill
12*:					
Agfayan	Severe: depth to rock, slope.	Severe: depth to rock, slope.	Severe: depth to rock, slope.	Severe: depth to rock, slope.	Poor: depth to rock, slope.
13*:					
Akina	Severe: percs slowly.	Moderate: seepage, slope.	Moderate: too clayey.	Slight	Fair: too clayey.
Atate	Severe: percs slowly.	Moderate: seepage, slope.	Severe: too clayey.	Slight	Poor: too clayey, hard to pack.
14*:					
Akina	Severe: percs slowly.	Severe: slope.	Moderate: slope, too clayey.	Moderate: slope.	Fair: too clayey, slope.
Atate	Severe: percs slowly.	Severe: slope.	Severe: too clayey.	Moderate: slope.	Poor: too clayey, hard to pack.
15*, 16*, 17*:					
Akina	Severe: percs slowly, slope.	Severe: slope.	Severe: slope.	Severe: slope.	Poor: slope.
Atate	Severe: percs slowly, slope.	Severe: slope.	Severe: slope, too clayey.	Severe: slope.	Poor: too clayey, hard to pack, slope.
18*:					
Akina	Severe: percs slowly.	Severe: slope.	Moderate: slope, too clayey.	Moderate: slope.	Fair: too clayey, slope.
Badland.					
19*, 20*, 21*:					
Akina	Severe: percs slowly, slope.	Severe: slope.	Severe: slope.	Severe: slope.	Poor: slope.
Badland.					
22*:					
Akina	Severe: percs slowly.	Moderate: seepage, slope.	Moderate: too clayey.	Slight	Fair: too clayey.
Urban land.					
23 Chacha	Severe: wetness, percs slowly.	Moderate: slope.	Severe: wetness.	Moderate: wetness.	Fair: too clayey, hard to pack, wetness.
24 Chacha Variant	Severe: wetness, percs slowly.	Severe: wetness.	Severe: wetness, too clayey.	Severe: wetness.	Poor: too clayey, hard to pack, wetness.

See footnote at end of table.

TABLE 8.--SANITARY FACILITIES--Continued

Soil name and map symbol	Septic tank absorption fields	Sewage lagoon areas	Trench sanitary landfill	Area sanitary landfill	Daily cover for landfill
25----------------- Guam	Severe: depth to rock.	Severe: depth to rock.	Severe: depth to rock, seepage.	Severe: depth to rock.	Poor: area reclaim.
26----------------- Guam	Severe: depth to rock.	Severe: depth to rock, slope.	Severe: depth to rock, seepage.	Severe: depth to rock.	Poor: area reclaim.
27*:					
Guam---------------	Severe: depth to rock.	Severe: depth to rock.	Severe: depth to rock, seepage.	Severe: depth to rock.	Poor: area reclaim.
Saipan-------------	Moderate: percs slowly.	Moderate: seepage.	Moderate: too clayey.	Slight-----------	Fair: too clayey, hard to pack.
28*:					
Guam---------------	Severe: depth to rock.	Severe: depth to rock.	Severe: depth to rock, seepage.	Severe: depth to rock.	Poor: area reclaim.
Urban land.					
29*:					
Guam---------------	Severe: depth to rock.	Severe: depth to rock.	Severe: depth to rock, seepage.	Severe: depth to rock.	Poor: area reclaim.
Yigo---------------	Moderate: depth to rock, percs slowly.	Moderate: seepage, depth to rock.	Severe: depth to rock, too clayey.	Moderate: depth to rock.	Poor: too clayey, hard to pack.
30----------------- Inarajan	Severe: flooding, wetness, percs slowly.	Severe: flooding.	Severe: flooding, wetness, too clayey.	Severe: flooding, wetness.	Poor: too clayey, hard to pack.
31----------------- Inarajan	Severe: flooding, wetness, percs slowly.	Severe: flooding.	Severe: flooding, wetness, too clayey.	Severe: flooding, wetness.	Poor: too clayey, too sandy, hard to pack.
32----------------- Inarajan Variant	Severe: flooding, wetness, percs slowly.	Severe: flooding, excess humus, wetness.	Severe: flooding, wetness, too clayey.	Severe: flooding, wetness.	Poor: too clayey, hard to pack, wetness.
33----------------- Pulantat	Severe: depth to rock.	Severe: depth to rock.	Severe: depth to rock, too clayey.	Severe: depth to rock.	Poor: depth to rock, too clayey, hard to pack.
34----------------- Pulantat	Severe: depth to rock.	Severe: depth to rock, slope.	Severe: depth to rock, too clayey.	Severe: depth to rock.	Poor: depth to rock, too clayey, hard to pack.
35, 36------------- Pulantat	Severe: depth to rock, slope.	Severe: depth to rock, slope.	Severe: depth to rock, slope, too clayey.	Severe: depth to rock, slope.	Poor: depth to rock, too clayey, hard to pack.

See footnote at end of table.

TABLE 8.--SANITARY FACILITIES--Continued

Soil name and map symbol	Septic tank absorption fields	Sewage lagoon areas	Trench sanitary landfill	Area sanitary landfill	Daily cover for landfill
37*:					
Pulantat	Severe: depth to rock.	Severe: depth to rock.	Severe: depth to rock, too clayey.	Severe: depth to rock.	Poor: depth to rock, too clayey, hard to pack.
Chacha	Severe: wetness, percs slowly.	Moderate: slope.	Severe: wetness.	Moderate: wetness.	Fair: too clayey, hard to pack, wetness.
38*:					
Pulantat	Severe: depth to rock.	Severe: depth to rock, slope.	Severe: depth to rock, too clayey.	Severe: depth to rock.	Poor: depth to rock, too clayey, hard to pack.
Chacha	Severe: wetness, percs slowly.	Moderate: slope.	Severe: wetness.	Moderate: wetness.	Fair: too clayey, hard to pack, wetness.
39*:					
Pulantat	Severe: depth to rock.	Severe: depth to rock.	Severe: depth to rock, too clayey.	Severe: depth to rock.	Poor: depth to rock, too clayey, hard to pack.
Kagman	Severe: percs slowly.	Slight	Severe: too clayey.	Slight	Poor: too clayey, hard to pack.
40*:					
Pulantat	Severe: depth to rock.	Severe: depth to rock, slope.	Severe: depth to rock, too clayey.	Severe: depth to rock.	Poor: depth to rock, too clayey, hard to pack.
Kagman	Severe: percs slowly.	Severe: slope.	Severe: too clayey.	Moderate: slope.	Poor: too clayey, hard to pack.
41*:					
Pulantat	Severe: depth to rock.	Severe: depth to rock.	Severe: depth to rock, too clayey.	Severe: depth to rock.	Poor: depth to rock, too clayey, hard to pack.
Urban land.					
42*:					
Pulantat	Severe: depth to rock.	Severe: depth to rock, slope.	Severe: depth to rock, too clayey.	Severe: depth to rock.	Poor: depth to rock, too clayey, hard to pack.
Urban land.					
43*:					
Ritidian	Severe: depth to rock, large stones.	Severe: depth to rock, slope, large stones.	Severe: depth to rock, seepage.	Severe: depth to rock.	Poor: depth to rock.

See footnote at end of table.

TABLE 8.--SANITARY FACILITIES--Continued

Soil name and map symbol	Septic tank absorption fields	Sewage lagoon areas	Trench sanitary landfill	Area sanitary landfill	Daily cover for landfill
43*: Rock outcrop.					
44*: Ritidian	Severe: depth to rock, slope, large stones.	Severe: depth to rock, slope, large stones.	Severe: depth to rock, seepage, slope.	Severe: depth to rock, slope.	Poor: depth to rock, slope.
Rock outcrop.					
45*: Rock outcrop.					
Ritidian	Severe: depth to rock, slope, large stones.	Severe: depth to rock, slope, large stones.	Severe: depth to rock, seepage, slope.	Severe: depth to rock, slope.	Poor: depth to rock, slope.
46 Sasalaguan	Severe: depth to rock, percs slowly.	Severe: depth to rock, slope.	Severe: depth to rock, too clayey.	Severe: depth to rock.	Poor: depth to rock, too clayey, hard to pack.
47 Shioya	Severe: poor filter.	Severe: seepage.	Severe: seepage, too sandy, excess salt.	Severe: seepage.	Poor: seepage, too sandy, excess salt.
48*: Togcha	Moderate: percs slowly.	Severe: slope.	Moderate: too clayey.	Slight	Fair: too clayey.
Akina	Severe: percs slowly.	Moderate: seepage, slope.	Moderate: too clayey.	Slight	Fair: too clayey.
49*: Togcha	Moderate: percs slowly, slope.	Severe: slope.	Moderate: slope, too clayey.	Moderate: slope.	Fair: too clayey, slope.
Akina	Severe: percs slowly.	Severe: slope.	Moderate: slope, too clayey.	Moderate: slope.	Fair: too clayey, slope.
50*: Togcha	Moderate: percs slowly.	Severe: slope.	Moderate: too clayey.	Slight	Fair: too clayey.
Ylig	Severe: wetness, percs slowly.	Severe: wetness.	Severe: wetness, too clayey.	Severe: wetness.	Poor: too clayey, hard to pack.
51*: Togcha	Moderate: percs slowly, slope.	Severe: slope.	Moderate: slope, too clayey.	Moderate: slope.	Fair: too clayey, slope.
Ylig	Severe: wetness, percs slowly.	Severe: slope, wetness.	Severe: wetness, too clayey.	Severe: wetness.	Poor: too clayey, hard to pack.

See footnote at end of table.

TABLE 8.--SANITARY FACILITIES--Continued

Soil name and map symbol	Septic tank absorption fields	Sewage lagoon areas	Trench sanitary landfill	Area sanitary landfill	Daily cover for landfill
52. Troposaprists					
53*: Urban land.					
Ustorthents.					
54, 55 Ylig	Severe: wetness, percs slowly.	Severe: wetness.	Severe: wetness, too clayey.	Severe: wetness.	Poor: too clayey, hard to pack.

* See description of the map unit for composition and behavior characteristics of the map unit.

TABLE 9.--CONSTRUCTION MATERIALS

[Some terms that describe restrictive soil features are defined in the Glossary. See text for definitions of "good," "fair," and other terms. Absence of an entry indicates that the soil was not rated. The information in this table indicates the dominant soil condition but does not eliminate the need for onsite investigation]

Soil name and map symbol	Roadfill	Sand	Gravel	Topsoil
1. Agfayan	Poor: depth to rock.	Improbable: excess fines.	Improbable: excess fines.	Poor: depth to rock, too clayey, slope.
2. Agfayan	Poor: depth to rock, slope.	Improbable: excess fines.	Improbable: excess fines.	Poor: depth to rock, too clayey, slope.
3*:				
Agfayan	Poor: depth to rock.	Improbable: excess fines.	Improbable: excess fines.	Poor: depth to rock, too clayey.
Rock outcrop.				
4*:				
Agfayan	Poor: depth to rock.	Improbable: excess fines.	Improbable: excess fines.	Poor: depth to rock, too clayey, slope.
Rock outcrop.				
5*:				
Agfayan	Poor: depth to rock, slope.	Improbable: excess fines.	Improbable: excess fines.	Poor: depth to rock, too clayey, slope.
Rock outcrop.				
6*:				
Agfayan	Poor: depth to rock, slope.	Improbable: excess fines.	Improbable: excess fines.	Poor: depth to rock, too clayey, slope.
Akina	Poor: low strength, slope.	Improbable: excess fines.	Improbable: excess fines.	Poor: too clayey, slope.
7*:				
Agfayan	Poor: depth to rock, slope.	Improbable: excess fines.	Improbable: excess fines.	Poor: depth to rock, too clayey, slope.
Akina	Poor: low strength, slope.	Improbable: excess fines.	Improbable: excess fines.	Poor: too clayey, slope.
Rock outcrop.				
8, 9. Akina	Poor: low strength.	Improbable: excess fines.	Improbable: excess fines.	Poor: too clayey.

See footnote at end of table.

TABLE 9.--CONSTRUCTION MATERIALS--Continued

Soil name and map symbol	Roadfill	Sand	Gravel	Topsoil
10------------------- Akina	Poor: low strength.	Improbable: excess fines.	Improbable: excess fines.	Poor: too clayey, slope.
11------------------- Akina	Poor: low strength, slope.	Improbable: excess fines.	Improbable: excess fines.	Poor: too clayey, slope.
12*:				
Akina----------------	Poor: low strength, slope.	Improbable: excess fines.	Improbable: excess fines.	Poor: too clayey, slope.
Agfayan--------------	Poor: depth to rock, slope.	Improbable: excess fines.	Improbable: excess fines.	Poor: depth to rock, too clayey, slope.
13*, 14*:				
Akina----------------	Poor: low strength.	Improbable: excess fines.	Improbable: excess fines.	Poor: too clayey.
Atate----------------	Fair: low strength.	Improbable: excess fines.	Improbable: excess fines.	Poor: too clayey.
15*:				
Akina----------------	Poor: low strength.	Improbable: excess fines.	Improbable: excess fines.	Poor: too clayey, slope.
Atate----------------	Fair: low strength, slope.	Improbable: excess fines.	Improbable: excess fines.	Poor: too clayey, slope.
16*, 17*:				
Akina----------------	Poor: low strength, slope.	Improbable: excess fines.	Improbable: excess fines.	Poor: too clayey, slope.
Atate----------------	Poor: slope.	Improbable: excess fines.	Improbable: excess fines.	Poor: too clayey, slope.
18*:				
Akina----------------	Poor: low strength.	Improbable: excess fines.	Improbable: excess fines.	Poor: too clayey.
Badland.				
19*:				
Akina----------------	Poor: low strength.	Improbable: excess fines.	Improbable: excess fines.	Poor: too clayey, slope.
Badland.				
20*, 21*:				
Akina----------------	Poor: low strength, slope.	Improbable: excess fines.	Improbable: excess fines.	Poor: too clayey, slope.
Badland.				

See footnote at end of table.

TABLE 9.--CONSTRUCTION MATERIALS--Continued

Soil name and map symbol	Roadfill	Sand	Gravel	Topsoil
22*:				
Akina	Poor: low strength.	Improbable: excess fines.	Improbable: excess fines.	Poor: too clayey.
Urban land.				
23 Chacha	Poor: shrink-swell.	Improbable: excess fines.	Improbable: excess fines.	Poor: too clayey.
24 Chacha Variant	Poor: low strength, wetness, shrink-swell.	Improbable: excess fines.	Improbable: excess fines.	Poor: too clayey, wetness.
25, 26 Guam	Poor: area reclaim.	Improbable: excess fines.	Improbable: excess fines.	Poor: area reclaim, small stones.
27*:				
Guam	Poor: area reclaim.	Improbable: excess fines.	Improbable: excess fines.	Poor: area reclaim, small stones.
Saipan	Fair: shrink-swell, low strength.	Improbable: excess fines.	Improbable: excess fines.	Poor: too clayey.
28*:				
Guam	Poor: area reclaim.	Improbable: excess fines.	Improbable: excess fines.	Poor: area reclaim, small stones.
Urban land.				
29*:				
Guam	Poor: area reclaim.	Improbable: excess fines.	Improbable: excess fines.	Poor: area reclaim, small stones.
Yigo	Poor: low strength.	Improbable: excess fines.	Improbable: excess fines.	Poor: too clayey.
30 Inarajan	Poor: low strength.	Improbable: excess fines.	Improbable: excess fines.	Poor: too clayey.
31 Inarajan	Poor: low strength.	Improbable: excess fines.	Improbable: excess fines.	Poor: too sandy, too clayey.
32 Inarajan Variant	Poor: wetness.	Improbable: excess fines.	Improbable: excess fines.	Poor: too clayey, wetness.
33, 34, 35, 36 Pulantat	Poor: depth to rock, shrink-swell, low strength.	Improbable: excess fines.	Improbable: excess fines.	Poor: depth to rock, too clayey, small stones.
37*, 38*:				
Pulantat	Poor: depth to rock, shrink-swell, low strength.	Improbable: excess fines.	Improbable: excess fines.	Poor: depth to rock, too clayey, small stones.

See footnote at end of table.

TABLE 9.--CONSTRUCTION MATERIALS--Continued

Soil name and map symbol	Roadfill	Sand	Gravel	Topsoil
37*, 38*:				
Chacha	Poor: shrink-swell.	Improbable: excess fines.	Improbable: excess fines.	Poor: too clayey.
39*, 40*:				
Pulantat	Poor: depth to rock, shrink-swell, low strength.	Improbable: excess fines.	Improbable: excess fines.	Poor: depth to rock, too clayey, small stones.
Kagman	Poor: shrink-swell, low strength.	Improbable: excess fines.	Improbable: excess fines.	Poor: too clayey.
41*, 42*:				
Pulantat	Poor: depth to rock, shrink-swell, low strength.	Improbable: excess fines.	Improbable: excess fines.	Poor: depth to rock, too clayey, small stones.
Urban land.				
43*:				
Ritidian	Poor: depth to rock, large stones.	Improbable: excess fines.	Improbable: excess fines.	Poor: depth to rock, small stones.
Rock outcrop.				
44*:				
Ritidian	Poor: depth to rock, large stones, slope.	Improbable: excess fines.	Improbable: excess fines.	Poor: depth to rock, small stones, slope.
Rock outcrop.				
45*:				
Rock outcrop.				
Ritidian	Poor: depth to rock, large stones, slope.	Improbable: excess fines.	Improbable: excess fines.	Poor: depth to rock, small stones, slope.
46 Sasalaguan	Poor: depth to rock.	Improbable: excess fines.	Improbable: excess fines.	Poor: too clayey.
47 Shioya	Good	Probable	Improbable: too sandy.	Poor: small stones, excess salt.
48*, 49*:				
Togcha	Poor: low strength.	Improbable: excess fines.	Improbable: excess fines.	Poor: too clayey.
Akina	Poor: low strength.	Improbable: excess fines.	Improbable: excess fines.	Poor: too clayey.
50*, 51*:				
Togcha	Poor: low strength.	Improbable: excess fines.	Improbable: excess fines.	Poor: too clayey.

See footnote at end of table.

TABLE 9.--CONSTRUCTION MATERIALS--Continued

Soil name and map symbol	Roadfill	Sand	Gravel	Topsoil
50*, 51*: Ylig	Poor: low strength.	Improbable: excess fines.	Improbable: excess fines.	Poor: too clayey.
52. Troposaprists				
53*: Urban land.				
Ustorthents.				
54, 55 Ylig	Poor: low strength.	Improbable: excess fines.	Improbable: excess fines.	Poor: too clayey.

* See description of the map unit for composition and behavior characteristics of the map unit.

TABLE 10.--WATER MANAGEMENT

[Some terms that describe restrictive soil features are defined in the Glossary. See text for definitions of "slight," "moderate," and "severe." Absence of an entry indicates that the soil was not evaluated. The information in this table indicates the dominant soil condition but does not eliminate the need for onsite investigation]

Soil name and map symbol	Limitations for-- Pond reservoir areas	Limitations for-- Embankments, dikes, and levees	Features affecting-- Drainage	Features affecting-- Terraces and diversions	Features affecting-- Grassed waterways
1, 2 Agfayan	Severe: depth to rock, slope.	Severe: thin layer.	Deep to water	Slope, depth to rock.	Slope, depth to rock.
3*, 4*, 5*:					
Agfayan	Severe: depth to rock, slope.	Severe: thin layer.	Deep to water	Slope, depth to rock.	Slope, depth to rock.
Rock outcrop.					
6*:					
Agfayan	Severe: depth to rock, slope.	Severe: thin layer.	Deep to water	Slope, depth to rock.	Slope, depth to rock.
Akina	Severe: slope.	Moderate: piping.	Deep to water	Slope	Slope.
7*:					
Agfayan	Severe: depth to rock, slope.	Severe: thin layer.	Deep to water	Slope, depth to rock.	Slope, depth to rock.
Akina	Severe: slope.	Moderate: piping.	Deep to water	Slope	Slope.
Rock outcrop.					
8 Akina	Moderate: slope.	Moderate: piping.	Deep to water	Favorable	Favorable.
9, 10, 11 Akina	Severe: slope.	Moderate: piping.	Deep to water	Slope	Slope.
12*:					
Akina	Severe: slope.	Moderate: piping.	Deep to water	Slope	Slope.
Agfayan	Severe: depth to rock, slope.	Severe: thin layer.	Deep to water	Slope, depth to rock.	Slope, depth to rock.
13*:					
Akina	Moderate: slope.	Moderate: piping.	Deep to water	Favorable	Favorable.
Atate	Moderate: seepage, slope.	Severe: hard to pack.	Deep to water	Favorable	Favorable.
14*, 15*, 16*, 17*:					
Akina	Severe: slope.	Moderate: piping.	Deep to water	Slope	Slope.

See footnote at end of table.

TABLE 10.--WATER MANAGEMENT--Continued

Soil name and map symbol	Limitations for-- Pond reservoir areas	Embankments, dikes, and levees	Features affecting-- Drainage	Terraces and diversions	Grassed waterways
14*, 15*, 16*, 17*:					
Atate-----------	Severe: slope.	Severe: hard to pack.	Deep to water----	Slope-----------	Slope.
18*, 19*, 20*, 21*:					
Akina-----------	Severe: slope.	Moderate: piping.	Deep to water----	Slope-----------	Slope.
Badland.					
22*:					
Akina------------	Moderate: slope.	Moderate: piping.	Deep to water----	Favorable--------	Favorable.
Urban land.					
23---------------- Chacha	Slight------------	Severe: hard to pack.	Percs slowly-----	Wetness, percs slowly.	Percs slowly.
24---------------- Chacha Variant	Slight------------	Severe: hard to pack, wetness.	Percs slowly-----	Wetness, percs slowly.	Wetness, percs slowly.
25---------------- Guam	Severe: depth to rock.	Severe: thin layer.	Deep to water----	Depth to rock----	Depth to rock.
26---------------- Guam	Severe: depth to rock, slope.	Severe: thin layer.	Deep to water----	Slope, depth to rock.	Slope, depth to rock.
27*:					
Guam-------------	Severe: depth to rock.	Severe: thin layer.	Deep to water----	Depth to rock----	Depth to rock.
Saipan-----------	Moderate: seepage.	Severe: hard to pack.	Deep to water----	Favorable--------	Droughty.
28*:					
Guam-------------	Severe: depth to rock.	Severe: thin layer.	Deep to water----	Depth to rock----	Depth to rock.
Urban land.					
29*:					
Guam-------------	Severe: depth to rock.	Severe: thin layer.	Deep to water----	Depth to rock----	Depth to rock.
Yigo-------------	Moderate: seepage, depth to rock.	Severe: hard to pack.	Deep to water----	Favorable--------	Droughty.
30---------------- Inarajan	Slight------------	Severe: hard to pack, wetness.	Percs slowly, flooding.	Wetness, percs slowly.	Percs slowly.
31---------------- Inarajan	Slight------------	Severe: hard to pack, wetness.	Percs slowly, flooding, cutbanks cave.	Wetness, too sandy, percs slowly.	Percs slowly.
32---------------- Inarajan Variant	Moderate: seepage.	Severe: wetness.	Percs slowly, flooding.	Wetness, percs slowly.	Wetness, percs slowly.

See footnote at end of table.

TABLE 10.--WATER MANAGEMENT--Continued

Soil name and map symbol	Limitations for-- Pond reservoir areas	Embankments, dikes, and levees	Features affecting-- Drainage	Terraces and diversions	Grassed waterways
33 Pulantat	Severe: depth to rock.	Severe: hard to pack.	Deep to water	Depth to rock, percs slowly.	Depth to rock, percs slowly.
34, 35, 36 Pulantat	Severe: depth to rock, slope.	Severe: hard to pack.	Deep to water	Slope, depth to rock, percs slowly.	Slope, depth to rock, percs slowly.
37*:					
Pulantat	Severe: depth to rock.	Severe: hard to pack.	Deep to water	Depth to rock, percs slowly.	Depth to rock, percs slowly.
Chacha	Slight	Severe: hard to pack.	Percs slowly	Wetness, percs slowly.	Percs slowly.
38*:					
Pulantat	Severe: depth to rock, slope.	Severe: hard to pack.	Deep to water	Slope, depth to rock, percs slowly.	Slope, depth to rock, percs slowly.
Chacha	Slight	Severe: hard to pack.	Percs slowly	Wetness, percs slowly.	Percs slowly.
39*:					
Pulantat	Severe: depth to rock.	Severe: hard to pack.	Deep to water	Depth to rock, percs slowly.	Depth to rock, percs slowly.
Kagman	Slight	Severe: hard to pack.	Deep to water	Percs slowly	Percs slowly.
40*:					
Pulantat	Severe: depth to rock, slope.	Severe: hard to pack.	Deep to water	Slope, depth to rock, percs slowly.	Slope, depth to rock, percs slowly.
Kagman	Severe: slope.	Severe: hard to pack.	Deep to water	Slope, percs slowly.	Slope, percs slowly.
41*:					
Pulantat	Severe: depth to rock.	Severe: hard to pack.	Deep to water	Depth to rock, percs slowly.	Depth to rock, percs slowly.
Urban land.					
42*:					
Pulantat	Severe: depth to rock, slope.	Severe: hard to pack.	Deep to water	Slope, depth to rock, percs slowly.	Slope, depth to rock, percs slowly.
Urban land.					
43*, 44*:					
Ritidian	Severe: depth to rock, slope.	Severe: large stones.	Deep to water	Slope, large stones, depth to rock.	Large stones, slope, droughty.
Rock outcrop.					
45*:					
Rock outcrop.					

See footnote at end of table.

TABLE 10.--WATER MANAGEMENT--Continued

Soil name and map symbol	Limitations for-- Pond reservoir areas	Limitations for-- Embankments, dikes, and levees	Features affecting-- Drainage	Features affecting-- Terraces and diversions	Features affecting-- Grassed waterways
45*:					
Ritidian	Severe: depth to rock, slope.	Severe: large stones.	Deep to water	Slope, large stones, depth to rock.	Large stones, slope, droughty.
46 Sasalaguan	Severe: slope.	Severe: hard to pack.	Deep to water	Slope, depth to rock, percs slowly.	Slope, depth to rock, percs slowly.
47 Shioya	Severe: seepage.	Severe: seepage, piping, excess salt.	Deep to water	Too sandy	Excess salt, droughty.
48*:					
Togcha	Moderate: seepage, slope.	Moderate: piping.	Deep to water	Favorable	Favorable.
Akina	Moderate: slope.	Moderate: piping.	Deep to water	Favorable	Favorable.
49*:					
Togcha	Severe: slope.	Moderate: piping.	Deep to water	Slope	Slope.
Akina	Severe: slope.	Moderate: piping.	Deep to water	Slope	Slope.
50*:					
Togcha	Moderate: seepage, slope.	Moderate: piping.	Deep to water	Favorable	Favorable.
Ylig	Moderate: slope.	Severe: hard to pack, wetness.	Slope	Wetness	Favorable.
51*:					
Togcha	Severe: slope.	Moderate: piping.	Deep to water	Slope	Slope.
Ylig	Severe: slope.	Severe: hard to pack, wetness.	Slope	Slope, wetness.	Slope.
52. Troposaprists					
53*:					
Urban land.					
Ustorthents.					
54 Ylig	Slight	Severe: hard to pack, wetness.	Favorable	Wetness	Favorable.
55 Ylig	Moderate: slope.	Severe: hard to pack, wetness.	Slope	Wetness	Favorable.

* See description of the map unit for composition and behavior characteristics of the map unit.

TABLE 11.--ENGINEERING INDEX PROPERTIES

[The symbol < means less than; > means more than. Absence of an entry indicates that data were not estimated]

Soil name and map symbol	Depth	USDA texture	Classification: Unified	Classification: AASHTO	Fragments > 8 centimeters	Percentage passing sieve number--: 4	10	40	200	Liquid limit	Plasticity index
	Cm				Pct					Pct	
1, 2------------- Agfayan	0-10	Clay-------------	CH, MH	A-7	0-5	95-100	85-100	80-100	60-95	70-80	35-45
	10-36	Clay-------------	CH, MH	A-7	0-5	95-100	85-100	80-100	65-95	70-80	35-45
	36	Weathered bedrock	---	---	---	---	---	---	---	---	---
3*, 4*, 5*:											
Agfayan----------	0-10	Clay-------------	CH, MH	A-7	0-5	95-100	85-100	80-100	60-95	70-80	35-45
	10-36	Clay-------------	CH, MH	A-7	0-5	95-100	85-100	80-100	65-95	70-80	35-45
	36	Weathered bedrock	---	---	---	---	---	---	---	---	---
Rock outcrop.											
6*:											
Agfayan----------	0-10	Clay-------------	CH, MH	A-7	0-5	95-100	85-100	80-100	60-95	70-80	35-45
	10-36	Clay-------------	CH, MH	A-7	0-5	95-100	85-100	80-100	65-95	70-80	35-45
	36	Weathered bedrock	---	---	---	---	---	---	---	---	---
Akina------------	0-10	Silty clay-------	MH	A-7	0	95-100	95-100	95-100	85-100	70-80	25-35
	10-61	Clay-------------	MH	A-7	0	95-100	95-100	90-100	75-100	75-85	25-35
	61	Weathered bedrock	---	---	---	---	---	---	---	---	---
7*:											
Agfayan----------	0-10	Clay-------------	CH, MH	A-7	0-5	95-100	85-100	80-100	60-95	70-80	35-45
	10-36	Clay-------------	CH, MH	A-7	0-5	95-100	85-100	80-100	65-95	70-80	35-45
	36	Weathered bedrock	---	---	---	---	---	---	---	---	---
Akina------------	0-10	Silty clay-------	MH	A-7	0	95-100	95-100	95-100	85-100	70-80	25-35
	10-61	Clay-------------	MH	A-7	0	95-100	95-100	90-100	75-100	75-85	25-35
	61	Weathered bedrock	---	---	---	---	---	---	---	---	---
Rock outcrop.											
8, 9, 10, 11------ Akina	0-10	Silty clay-------	MH	A-7	0	95-100	95-100	95-100	85-100	70-80	25-35
	10-61	Clay-------------	MH	A-7	0	95-100	95-100	90-100	75-100	75-85	25-35
	61	Weathered bedrock	---	---	---	---	---	---	---	---	---
12*:											
Akina------------	0-10	Silty clay-------	MH	A-7	0	95-100	95-100	95-100	85-100	70-80	25-35
	10-61	Clay-------------	MH	A-7	0	95-100	95-100	90-100	75-100	75-85	25-35
	61	Weathered bedrock	---	---	---	---	---	---	---	---	---
Agfayan----------	0-10	Clay-------------	CH, MH	A-7	0-5	95-100	85-100	80-100	60-95	70-80	35-45
	10-36	Clay-------------	CH, MH	A-7	0-5	95-100	85-100	80-100	65-95	70-80	35-45
	36	Weathered bedrock	---	---	---	---	---	---	---	---	---
13*, 14*, 15*, 16*, 17*:											
Akina------------	0-10	Silty clay-------	MH	A-7	0	95-100	95-100	95-100	85-100	70-80	25-35
	10-61	Clay-------------	MH	A-7	0	95-100	95-100	90-100	75-100	75-85	25-35
	61	Weathered bedrock	---	---	---	---	---	---	---	---	---
Atate------------	0-13	Silty clay-------	MH	A-7	0	100	95-100	95-100	90-100	75-85	20-30
	13-109	Clay-------------	MH	A-7	0	100	100	95-100	95-100	75-85	25-35
	109-165	Clay-------------	MH	A-7	0-3	100	100	95-100	95-100	75-85	25-35
18*, 19*, 20*, 21*:											
Akina------------	0-10	Silty clay-------	MH	A-7	0	95-100	95-100	95-100	85-100	70-80	25-35
	10-61	Clay-------------	MH	A-7	0	95-100	95-100	90-100	75-100	75-85	25-35
	61	Weathered bedrock	---	---	---	---	---	---	---	---	---

See footnote at end of table.

TABLE 11.--ENGINEERING INDEX PROPERTIES--Continued

Soil name and map symbol	Depth	USDA texture	Classification		Fragments > 8 centimeters	Percentage passing sieve number-				Liquid limit	Plasticity index
			Unified	AASHTO		4	10	40	200		
	Cm				Pct					Pct	
18*, 19*, 20*, 21*: Badland.											
22*: Akina-----------	0-10	Silty clay-------	MH	A-7	0	95-100	95-100	95-100	85-100	70-80	25-35
	10-61	Clay-------------	MH	A-7	0	95-100	95-100	90-100	75-100	75-85	25-35
	61	Weathered bedrock	---	---	---	---	---	---	---	---	---
Urban land.											
23--------------- Chacha	0-20	Clay-------------	MH	A-7	0	95-100	95-100	95-100	65-100	60-75	20-30
	20-109	Clay-------------	MH	A-7	0	100	100	95-100	95-100	90-100	45-55
	109	Weathered bedrock	---	---	---	---	---	---	---	---	---
24--------------- Chacha Variant	0-28	Clay-------------	MH	A-7	0	100	100	90-100	80-100	60-75	20-30
	28-152	Clay-------------	MH	A-7	0	100	100	95-100	95-100	90-100	45-55
25, 26----------- Guam	0-5	Cobbly clay loam	OH, MH	A-7	10-30	75-90	70-85	55-80	50-75	55-70	10-20
	5-20	Gravelly clay loam, gravelly silty clay, cobbly clay.	MH	A-7	5-25	65-90	60-85	50-75	40-70	50-65	15-25
	20	Unweathered bedrock.	---	---	---	---	---	---	---	---	---
27*: Guam------------	0-5	Cobbly clay loam	OH, MH	A-7	10-30	75-90	70-85	55-80	50-75	55-70	10-20
	5-20	Gravelly clay loam, gravelly silty clay, cobbly clay.	MH	A-7	5-25	65-90	60-85	50-75	40-70	50-65	15-25
	20	Unweathered bedrock.	---	---	---	---	---	---	---	---	---
Saipan----------	0-15	Silty clay-------	ML, MH	A-7	0	90-100	85-100	80-100	70-95	45-65	15-30
	15-140	Silty clay, clay	ML, MH	A-7	0	100	100	90-100	80-95	40-70	10-30
28*: Guam------------	0-5	Cobbly clay loam	OH, MH	A-7	10-30	75-90	70-85	55-80	50-75	55-70	10-20
	5-20	Gravelly clay loam, gravelly silty clay, cobbly clay.	MH	A-7	5-25	65-90	60-85	50-75	40-70	50-65	15-25
	20	Unweathered bedrock.	---	---	---	---	---	---	---	---	---
Urban land.											
29*: Guam------------	0-5	Cobbly clay loam	OH, MH	A-7	10-30	75-90	70-85	55-80	50-75	55-70	10-20
	5-20	Gravelly clay loam, gravelly silty clay, cobbly clay.	MH	A-7	5-25	65-90	60-85	50-75	40-70	50-65	15-25
	20	Unweathered bedrock.	---	---	---	---	---	---	---	---	---
Yigo------------	0-15	Silty clay-------	ML, MH	A-7	0	95-100	95-100	85-100	80-95	45-60	10-25
	15-162	Silty clay, clay	ML, MH	A-7	0-5	95-100	95-100	85-100	80-95	45-60	10-25

See footnote at end of table.

TABLE 11.--ENGINEERING INDEX PROPERTIES--Continued

Soil name and map symbol	Depth	USDA texture	Classification		Fragments > 8 centimeters	Percentage passing sieve number-				Liquid limit	Plasticity index
			Unified	AASHTO		4	10	40	200		
	Cm				Pct					Pct	
30----------------	0-25	Clay--------------	MH	A-7	0	100	100	90-100	70-95	70-90	30-50
Inarajan	25-41	Clay, silty clay	MH	A-7	0	100	100	90-100	70-95	70-90	30-50
	41-145	Silty clay, clay	MH	A-7	0	100	95-100	85-100	70-95	60-80	20-40
31----------------	0-20	Sandy clay loam	SC	A-7, A-6	0	100	100	65-75	35-50	30-45	10-20
Inarajan	20-152	Stratified sand to clay.	MH	A-7	0	100	95-100	85-95	70-85	60-80	20-40
32----------------	0-5	Mucky clay--------	OH	A-7	0	100	100	90-100	90-95	70-90	10-25
Inarajan Variant	5-130	Clay, silty clay	MH	A-7	0	100	100	90-100	85-95	70-90	30-50
	130-160	Hemic material---	PT	A-8	0-5	---	---	---	---	---	---
33, 34, 35, 36---	0-8	Clay--------------	MH	A-7	0-5	90-100	85-100	80-100	70-100	60-80	20-35
Pulantat	8-18	Clay, gravelly clay.	MH, CH	A-7	0-5	80-100	75-100	70-100	70-100	80-100	45-65
	18-30	Very gravelly clay.	GC, CH	A-2, A-7	5-15	40-60	30-60	30-60	25-60	80-100	45-65
	30	Unweathered bedrock.	---	---	---	---	---	---	---	---	---
37*, 38*:											
Pulantat---------	0-8	Clay--------------	MH	A-7	0-5	90-100	85-100	80-100	70-100	60-80	20-35
	8-18	Clay, gravelly clay.	MH, CH	A-7	0-5	80-100	75-100	70-100	70-100	80-100	45-65
	18-30	Very gravelly clay.	GC, CH	A-2, A-7	5-15	40-60	30-60	30-60	25-60	80-100	45-65
	30	Unweathered bedrock.	---	---	---	---	---	---	---	---	---
Chacha-----------	0-20	Clay--------------	MH	A-7	0	95-100	95-100	95-100	65-100	60-75	20-30
	20-109	Clay--------------	MH	A-7	0	100	100	95-100	95-100	90-100	45-55
	109	Weathered bedrock	---	---	---	---	---	---	---	---	---
39*, 40*:											
Pulantat---------	0-8	Clay--------------	MH	A-7	0-5	90-100	85-100	80-100	70-100	60-80	20-35
	8-18	Clay, gravelly clay.	MH, CH	A-7	0-5	80-100	75-100	70-100	70-100	80-100	45-65
	18-30	Very gravelly clay.	GC, CH	A-2, A-7	5-15	40-60	30-60	30-60	25-60	80-100	45-65
	30	Unweathered bedrock.	---	---	---	---	---	---	---	---	---
Kagman-----------	0-16	Clay--------------	MH	A-7	0-5	90-100	85-100	80-100	75-100	60-80	20-30
	16-150	Clay--------------	MH	A-7	0	100	100	95-100	90-100	80-100	30-50
41*, 42*:											
Pulantat---------	0-8	Clay--------------	MH	A-7	0-5	90-100	85-100	80-100	70-100	60-80	20-35
	8-18	Clay, gravelly clay.	MH, CH	A-7	0-5	80-100	75-100	70-100	70-100	80-100	45-65
	18-30	Very gravelly clay.	GC, CH	A-2, A-7	5-15	40-60	30-60	30-60	25-60	80-100	45-65
	30	Unweathered bedrock.	---	---	---	---	---	---	---	---	---
Urban land.											

See footnote at end of table.

TABLE 11.--ENGINEERING INDEX PROPERTIES--Continued

Soil name and map symbol	Depth	USDA texture	Classification		Fragments > 8 centimeters	Percentage passing sieve number--				Liquid limit	Plasticity index
			Unified	AASHTO		4	10	40	200		
	Cm				Pct					Pct	
43*, 44*:											
Ritidian	0-10	Extremely cobbly clay loam.	GM, GP-GM	A-2	45-65	20-45	10-45	10-40	10-35	50-65	10-25
	10-25	Extremely cobbly clay loam, extremely cobbly clay.	GM, GP-GM	A-2	45-65	20-45	10-45	10-40	10-35	50-75	10-30
	25	Unweathered bedrock.	---	---	---	---	---	---	---	---	---
Rock outcrop.											
45*:											
Rock outcrop.											
Ritidian	0-10	Extremely cobbly clay loam.	GM, GP-GM	A-2	45-65	20-45	10-45	10-40	10-35	50-65	10-25
	10-25	Extremely cobbly clay loam, extremely cobbly clay.	GM, GP-GM	A-2	45-65	20-45	10-45	10-40	10-35	50-75	10-30
	25	Unweathered bedrock.	---	---	---	---	---	---	---	---	---
46 Sasalaguan	0-13	Clay	CH	A-7	0	100	100	95-100	95-100	80-100	50-60
	13-71	Clay	CH	A-7	0	100	100	95-100	95-100	80-100	50-60
	71	Weathered bedrock	---	---	---	---	---	---	---	---	---
47 Shioya	0-25	Loamy sand	SM	A-2	0-5	90-100	85-95	50-65	15-25	---	NP
	25-152	Sand	SP-SM, SP	A-3, A-2	0-10	85-95	80-95	50-60	0-10	---	NP
48*, 49*:											
Togcha	0-13	Silty clay	MH	A-7	0	100	100	95-100	80-95	65-70	15-20
	13-71	Silty clay, clay	MH	A-7	0	100	100	95-100	80-95	65-80	20-30
	71-152	Clay, silty clay	MH	A-7	0	100	100	95-100	80-95	65-80	20-30
Akina	0-10	Silty clay	MH	A-7	0	95-100	95-100	95-100	85-100	70-80	25-35
	10-61	Clay	MH	A-7	0	95-100	95-100	90-100	75-100	75-85	25-35
	61	Weathered bedrock	---	---	---	---	---	---	---	---	---
50*, 51*:											
Togcha	0-13	Silty clay	MH	A-7	0	100	100	95-100	80-95	65-70	15-20
	13-71	Silty clay, clay	MH	A-7	0	100	100	95-100	80-95	65-80	20-30
	71-152	Clay, silty clay	MH	A-7	0	100	100	95-100	80-95	65-80	20-30
Ylig	0-13	Clay	MH	A-7	0	100	100	90-100	70-95	70-90	30-50
	13-160	Clay, silty clay	MH	A-7	0	90-100	85-100	75-100	70-95	60-80	20-40
52. Troposaprists											
53*:											
Urban land.											
Ustorthents.											
54, 55 Ylig	0-13	Clay	MH	A-7	0	100	100	90-100	70-95	70-90	30-50
	13-160	Clay, silty clay	MH	A-7	0	90-100	85-100	75-100	70-95	60-80	20-40

* See description of the map unit for composition and behavior characteristics of the map unit.

TABLE 12.--PHYSICAL AND CHEMICAL PROPERTIES OF THE SOILS

[The symbol < means less than; > means more than. Entries under "Erosion factors--T" apply to the entire profile. Entries under "Organic matter" apply only to the surface layer. Absence of an entry indicates that data were not available or were not estimated]

Soil name and map symbol	Depth	Clay	Moist bulk density	Permea- bility	Available water capacity	Soil reaction	Salinity	Shrink- swell potential	Erosion factors		Organic matter
									K	T	
	Cm	Pct	G/cc	Cm/hr	Cm/cm	pH	mmhos/cm				Pct
1, 2------------- Agfayan	0-10	60-80	0.80-0.95	0.5-1.5	0.20-0.25	6.1-7.3	<2	High------	0.20	2	2-5
	10-36	60-80	0.80-0.95	0.5-1.5	0.13-0.16	6.1-7.3	<2	High------	0.20		
	36	---	---	---	---	---	---	----------	----		
3*, 4*, 5*:											
Agfayan---------	0-10	60-80	0.80-0.95	0.5-1.5	0.20-0.25	6.1-7.3	<2	High------	0.20	2	2-5
	10-36	60-80	0.80-0.95	0.5-1.5	0.13-0.16	6.1-7.3	<2	High------	0.20		
	36	---	---	---	---	---	---	----------	----		
Rock outcrop.											
6*:											
Agfayan---------	0-10	60-80	0.80-0.95	0.5-1.5	0.20-0.25	6.1-7.3	<2	High------	0.20	2	2-5
	10-36	60-80	0.80-0.95	0.5-1.5	0.13-0.16	6.1-7.3	<2	High------	0.20		
	36	---	---	---	---	---	---	----------	----		
Akina-----------	0-10	45-60	0.85-1.00	1.5-5.0	0.17-0.20	5.1-7.3	<2	Moderate	0.20	3	6-10
	10-61	60-80	1.00-1.20	0.5-1.5	0.08-0.10	4.5-6.0	<2	Moderate	0.15		
	61	---	---	---	---	---	---	----------	----		
7*:											
Agfayan---------	0-10	60-80	0.80-0.95	0.5-1.5	0.20-0.25	6.1-7.3	<2	High------	0.20	2	2-5
	10-36	60-80	0.80-0.95	0.5-1.5	0.13-0.16	6.1-7.3	<2	High------	0.20		
	36	---	---	---	---	---	---	----------	----		
Akina-----------	0-10	45-60	0.85-1.00	1.5-5.0	0.17-0.20	5.1-7.3	<2	Moderate	0.20	3	6-10
	10-61	60-80	1.00-1.20	0.5-1.5	0.08-0.10	4.5-6.0	<2	Moderate	0.15		
	61	---	---	---	---	---	---	----------	----		
Rock outcrop.											
8, 9, 10, 11----- Akina	0-10	45-60	0.85-1.00	1.5-5.0	0.17-0.20	5.1-7.3	<2	Moderate	0.20	3	6-10
	10-61	60-80	1.00-1.20	0.5-1.5	0.08-0.10	4.5-6.0	<2	Moderate	0.15		
	61	---	---	---	---	---	---	----------	----		
12*:											
Akina-----------	0-10	45-60	0.85-1.00	1.5-5.0	0.17-0.20	5.1-7.3	<2	Moderate	0.20	3	6-10
	10-61	60-80	1.00-1.20	0.5-1.5	0.08-0.10	4.5-6.0	<2	Moderate	0.15		
	61	---	---	---	---	---	---	----------	----		
Agfayan---------	0-10	60-80	0.80-0.95	0.5-1.5	0.20-0.25	6.1-7.3	<2	High------	0.20	2	2-5
	10-36	60-80	0.80-0.95	0.5-1.5	0.13-0.16	6.1-7.3	<2	High------	0.20		
	36	---	---	---	---	---	---	----------	----		
13*, 14*, 15*, 16*, 17*:											
Akina----------	0-10	45-60	0.85-1.00	1.5-5.0	0.17-0.20	5.1-7.3	<2	Moderate	0.20	3	6-10
	10-61	60-80	1.00-1.20	0.5-1.5	0.08-0.10	4.5-6.0	<2	Moderate	0.15		
	61	---	---	---	---	---	---	----------	----		
Atate----------	0-13	40-60	0.90-1.10	1.5-5.0	0.15-0.20	4.5-6.5	<2	Moderate	0.15	5	4-8
	13-109	60-90	1.00-1.20	1.5-5.0	0.07-0.12	4.5-6.0	<2	Moderate	0.15		
	109-165	60-90	1.00-1.20	1.5-5.0	0.07-0.12	4.5-6.0	<2	Moderate	0.15		

See footnote at end of table.

TABLE 12.--PHYSICAL AND CHEMICAL PROPERTIES OF THE SOILS--Continued

Soil name and map symbol	Depth	Clay	Moist bulk density	Permea-bility	Available water capacity	Soil reaction	Salinity	Shrink-swell potential	Erosion factors K	Erosion factors T	Organic matter
	Cm	Pct	G/cc	Cm/hr	Cm/cm	pH	mmhos/cm				Pct
18*, 19*, 20*, 21*:											
Akina----------	0-10	45-60	0.85-1.00	1.5-5.0	0.17-0.20	5.1-7.3	<2	Moderate	0.20	3	6-10
	10-61	60-80	1.00-1.20	0.5-1.5	0.08-0.10	4.5-6.0	<2	Moderate	0.15		
	61	---	---	---	---	---	---	----------	----		
Badland.											
22*:											
Akina-----------	0-10	45-60	0.85-1.00	1.5-5.0	0.17-0.20	5.1-7.3	<2	Moderate	0.20	3	6-10
	10-61	60-80	1.00-1.20	0.5-1.5	0.08-0.10	4.5-6.0	<2	Moderate	0.15		
	61	---	---	---	---	---	---	----------	----		
Urban land.											
23--------------- Chacha	0-20	50-60	1.00-1.20	0.02-0.5	0.10-0.15	5.6-7.8	<2	High------	0.15	5	4-8
	20-109	60-90	1.00-1.20	0.02-0.5	0.10-0.15	5.1-7.8	<2	High------	0.15		
	109	---	---	---	---	---	<2	High------	0.15		
24--------------- Chacha Variant	0-31	65-80	1.00-1.20	0.02-0.5	0.10-0.15	6.1-7.3	<2	High------	0.15	5	4-8
	31-152	70-90	1.00-1.20	0.02-0.5	0.10-0.15	5.1-7.8	<2	High------	0.15		
25, 26----------- Guam	0-10	35-40	0.60-0.90	5.0-15.0	0.18-0.24	6.6-7.8	<2	Low-------	0.05	1	10-15
	10-25	35-55	0.60-0.90	5.0-15.0	0.18-0.24	6.6-7.8	<2	Low-------	0.05		
	25	---	---	---	---	---	---	----------	----		
27*:											
Guam-----------	0-10	35-40	0.60-0.90	5.0-15.0	0.18-0.24	6.6-7.8	<2	Low-------	0.05	1	10-15
	10-25	35-55	0.60-0.90	5.0-15.0	0.18-0.24	6.6-7.8	<2	Low-------	0.05		
	25	---	---	---	---	---	---	----------	----		
Saipan---------	0-15	35-60	1.00-1.20	1.5-5.0	0.10-0.13	6.1-7.8	<2	Moderate	0.15	5	4-7
	15-140	35-60	1.20-1.40	1.5-5.0	0.10-0.13	6.1-7.8	<2	Moderate	0.15		
28*:											
Guam-----------	0-10	35-40	0.60-0.90	5.0-15.0	0.18-0.24	6.6-7.8	<2	Low-------	0.05	1	10-15
	10-25	35-55	0.60-0.90	5.0-15.0	0.18-0.24	6.6-7.8	<2	Low-------	0.05		
	25	---	---	---	---	---	---	----------	----		
Urban land.											
29*:											
Guam-----------	0-10	35-40	0.60-0.90	5.0-15.0	0.18-0.24	6.6-7.8	<2	Low-------	0.05	1	10-15
	10-25	35-55	0.60-0.90	5.0-15.0	0.18-0.24	6.6-7.8	<2	Low-------	0.05		
	25	---	---	---	---	---	---	----------	----		
Yigo-----------	0-15	40-60	0.90-1.10	1.5-5.0	0.08-0.13	5.6-7.3	<2	Low-------	0.20	4	4-8
	15-162	40-60	1.00-1.20	1.5-5.0	0.05-0.10	6.1-7.8	<2	Low-------	0.20		
30--------------- Inarajan	0-25	45-80	0.90-1.10	0.02-0.5	0.18-0.20	5.1-7.3	<2	High------	0.24	5	5-7
	25-41	60-80	0.90-1.10	0.02-0.5	0.13-0.15	6.1-8.4	<2	High------	0.28		
	41-145	60-80	0.90-1.10	0.02-0.5	0.11-0.13	6.1-8.4	<2	Moderate	0.17		
31--------------- Inarajan	0-20	20-35	1.00-1.20	0.02-5.0	0.10-0.15	7.4-8.4	2-4	Low-------	0.17	5	4-7
	20-150	60-70	1.00-1.20	0.02-0.5	0.15-0.18	7.4-8.4	2-4	Moderate	0.24		
32--------------- Inarajan Variant	0-5	50-70	0.70-0.90	0.5-1.5	0.18-0.20	6.6-7.8	<2	Moderate	0.28	5	12-18
	5-130	60-80	1.00-1.20	0.02-0.5	0.12-0.15	6.1-8.4	2-4	High------	0.28		
	130-150	---	0.25-0.50	1.5-5.0	0.25-0.30	6.1-8.4	2-8	Low-------	0.02		
	150-160										

See footnote at end of table.

TABLE 12.--PHYSICAL AND CHEMICAL PROPERTIES OF THE SOILS--Continued

Soil name and map symbol	Depth	Clay	Moist bulk density	Permea-bility	Available water capacity	Soil reaction	Salinity	Shrink-swell potential	Erosion factors K	Erosion factors T	Organic matter
	Cm	Pct	G/cc	Cm/hr	Cm/cm	pH	mmhos/cm				Pct
33, 34, 35, 36---Pulantat	0-18	60-80	0.80-1.00	0.02-0.5	0.17-0.20	6.1-7.3	<2	Moderate	0.24	1	7-10
	18-31	70-90	0.90-1.10	0.02-0.5	0.15-0.20	6.6-7.8	<2	High------	0.28		
	31-41	70-90	0.90-1.10	0.02-0.5	0.05-0.10	7.4-8.4	<2	High------	0.10		
	41	---	---	---	---	---	---	---------	----		
37*, 38*:											
Pulantat--------	0-18	60-80	0.80-1.00	0.02-0.5	0.17-0.20	6.1-7.3	<2	Moderate	0.24	1	7-10
	18-31	70-90	0.90-1.10	0.02-0.5	0.15-0.20	6.6-7.8	<2	High------	0.28		
	31-41	70-90	0.90-1.10	0.02-0.5	0.05-0.10	7.4-8.4	<2	High------	0.10		
	41	---	---	---	---	---	---	---------	----		
Chacha----------	0-20	50-60	1.00-1.20	0.02-0.5	0.10-0.15	5.6-7.8	<2	High------	0.15	5	4-8
	20-109	60-90	1.00-1.20	0.02-0.5	0.10-0.15	5.1-7.8	<2	High------	0.15		
	109	---	---	---	---	---	<2	High------	0.15		
39*, 40*:											
Pulantat--------	0-18	60-80	0.80-1.00	0.02-0.5	0.17-0.20	6.1-7.3	<2	Moderate	0.24	1	7-10
	18-31	70-90	0.90-1.10	0.02-0.5	0.15-0.20	6.6-7.8	<2	High------	0.28		
	31-41	70-90	0.90-1.10	0.02-0.5	0.05-0.10	7.4-8.4	<2	High------	0.10		
	41	---	---	---	---	---	---	---------	----		
Kagman----------	0-16	40-70	0.90-1.20	0.5-1.5	0.12-0.18	6.1-7.8	<2	High------	0.15	5	4-8
	16-150	60-90	1.00-1.20	0.5-1.5	0.10-0.15	5.1-7.8	<2	High------	0.15		
41*, 42*:											
Pulantat--------	0-18	60-80	0.80-1.00	0.02-0.5	0.17-0.20	6.1-7.3	<2	Moderate	0.24	1	7-10
	18-31	70-90	0.90-1.10	0.02-0.5	0.15-0.20	6.6-7.8	<2	High------	0.28		
	31-41	70-90	0.90-1.10	0.02-0.5	0.05-0.10	7.4-8.4	<2	High------	0.10		
	41	---	---	---	---	---	---	---------	----		
Urban land.											
43*, 44*:											
Ritidian--------	0-10	35-40	0.70-0.90	5.0-15.0	0.05-0.08	6.6-7.8	<2	Low-------	0.02	1	6-9
	10-25	35-60	0.70-0.90	5.0-15.0	0.05-0.08	6.6-7.8	<2	Low-------	0.02		
	25	---	---	---	---	---	---	---------	----		
Rock outcrop.											
45*:											
Rock outcrop.											
Ritidian--------	0-10	35-40	0.70-0.90	5.0-15.0	0.05-0.08	6.6-7.8	<2	Low-------	0.02	1	6-9
	10-25	35-60	0.70-0.90	5.0-15.0	0.05-0.08	6.6-7.8	<2	Low-------	0.02		
	25	---	---	---	---	---	---	---------	----		
46--------------Sasalaguan	0-13	45-75	0.80-1.00	0.02-0.5	0.15-0.18	5.1-6.5	<2	High------	0.28	4	4-7
	13-71	60-80	0.80-1.00	0.02-0.5	0.11-0.15	5.1-6.5	<2	High------	0.28		
	71	---	---	---	---	---	---	---------	----		
47--------------Shioya	0-25	0-3	1.10-1.25	15.0-50	0.08-0.10	7.4-8.4	8-16	Low-------	0.15	5	4-5
	25-152	0-5	1.20-1.30	15.0-50	0.05-0.08	7.4-9.0	16	Low-------	0.10		
48*, 49*:											
Togcha----------	0-13	55-60	0.95-1.10	1.5-5.0	0.10-0.15	5.1-6.0	<2	Moderate	0.15	5	4-7
	13-71	60-80	0.95-1.10	1.5-5.0	0.08-0.13	5.1-6.0	<2	Moderate	0.15		
	71-152	60-80	0.95-1.10	1.5-5.0	0.08-0.13	5.1-6.0	<2	Moderate	0.15		
Akina-----------	0-10	45-60	0.85-1.00	1.5-5.0	0.17-0.20	5.1-7.3	<2	Moderate	0.20	3	6-10
	10-61	60-80	1.00-1.20	0.5-1.5	0.08-0.10	4.5-6.0	<2	Moderate	0.15		
	61	---	---	---	---	---	---	---------	----		

See footnote at end of table.

TABLE 12.--PHYSICAL AND CHEMICAL PROPERTIES OF THE SOILS--Continued

Soil name and map symbol	Depth	Clay	Moist bulk density	Permea-bility	Available water capacity	Soil reaction	Salinity	Shrink-swell potential	Erosion factors K	Erosion factors T	Organic matter
	Cm	Pct	G/cc	Cm/hr	Cm/cm	pH	mmhos/cm				Pct
50*, 51*:											
Togcha----------	0-13	55-60	0.95-1.10	1.5-5.0	0.10-0.15	5.1-6.0	<2	Moderate	0.15	5	4-7
	13-71	60-80	0.95-1.10	1.5-5.0	0.08-0.13	5.1-6.0	<2	Moderate	0.15		
	71-152	60-80	0.95-1.10	1.5-5.0	0.08-0.13	5.1-6.0	<2	Moderate	0.15		
Ylig------------	0-13	50-70	0.90-1.10	0.5-1.5	0.18-0.20	5.1-6.5	<2	High------	0.24	5	6-8
	13-160	35-60	0.90-1.10	0.5-1.5	0.15-0.18	4.5-6.0	<2	Moderate	0.17		
52. Troposaprists											
53*: Urban land.											
Ustorthents.											
54, 55----------- Ylig	0-13	50-70	0.90-1.10	0.5-1.5	0.18-0.20	5.1-6.5	<2	High------	0.24	5	6-8
	13-160	35-60	0.90-1.10	0.5-1.5	0.15-0.18	4.5-6.0	<2	Moderate	0.17		

* See description of the map unit for composition and behavior characteristics of the map unit.

TABLE 13.--SOIL AND WATER FEATURES

["Flooding" and "water table" and terms such as "rare," "brief," "apparent," and "perched" are explained in the text. The symbol < means less than; > means more than. Absence of an entry indicates that the feature is not a concern or that data were not estimated]

Soil name and map symbol	Hydrologic group	Flooding			High water table*			Bedrock		Risk of corrosion	
		Frequency	Duration	Months	Depth	Kind	Months	Depth	Hardness	Uncoated steel	Concrete
					Cm			Cm			
1, 2: Agfayan	D	None	---	---	>180	---	---	10-38	Soft	Moderate	Low.
3**, 4**, 5**:											
Agfayan	D	None	---	---	>180	---	---	10-38	Soft	Moderate	Low.
Rock outcrop.											
6**:											
Agfayan	D	None	---	---	>180	---	---	10-38	Soft	Moderate	Low.
Akina	B	None	---	---	>180	---	---	51-102	---	Moderate	Moderate.
7**:											
Agfayan	D	None	---	---	>180	---	---	10-38	Soft	Moderate	Low.
Akina	B	None	---	---	>180	---	---	51-102	---	High	High.
Rock outcrop.											
8, 9, 10, 11: Akina	B	None	---	---	>180	---	---	51-102	---	Moderate	Moderate.
12**:											
Akina	B	None	---	---	>180	---	---	51-102	---	Moderate	Moderate.
Agfayan	D	None	---	---	>180	---	---	10-38	Soft	Moderate	Low.
13**, 14**, 15**, 16**, 17**:											
Akina	B	None	---	---	>180	---	---	51-102	---	Moderate	Moderate.
Atate	B	None	---	---	>180	---	---	>102	Soft	High	High.
18**, 19**, 20**, 21**:											
Akina	B	None	---	---	>180	---	---	51-102	---	Moderate	Moderate.
Badland.											

See footnotes at end of table.

TABLE 13.--SOIL AND WATER FEATURES--Continued

Soil name and map symbol	Hydrologic group	Flooding			High water table*			Bedrock		Risk of corrosion	
		Frequency	Duration	Months	Depth	Kind	Months	Depth	Hardness	Uncoated steel	Concrete
					Cm			Cm			
22**:											
Akina	B	None	---	---	>180	---	---	51-102	---	Moderate	Moderate.
Urban land.											
23 Chacha	C	Rare	---	---	51-91	Perched	Jul-Dec	>102	Soft	Moderate	Moderate.
24 Chacha Variant	D	Occasional	Brief	Jun-Nov	+30-60	Apparent	Jul-Nov	>152	---	Moderate	Moderate.
25, 26 Guam	D	None	---	---	>180	---	---	5-41	Hard	Moderate	Low.
27**:											
Guam	D	None	---	---	>180	---	---	5-41	Hard	Moderate	Low.
Saipan	B	None	---	---	>180	---	---	>100	---	Moderate	Low.
28**:											
Guam	D	None	---	---	>180	---	---	5-25	Hard	Moderate	Low.
Urban land.											
29**:											
Guam	D	None	---	---	>180	---	---	5-41	Hard	Moderate	Low.
Yigo	B	None	---	---	>180	---	---	>102	Hard	Moderate	Moderate.
30 Inarajan	D	Occasional	Brief	Jun-Nov	51-102	Apparent	Jul-Dec	>102	---	High	Moderate.
31 Inarajan	C	Occasional	Brief	Jun-Nov	51-102	Apparent	Jul-Dec	>102	---	High	High.
32 Inarajan Variant	D	Frequent	Brief	Jun-Nov	+50-50	Apparent	Jan-Dec	>152	---	High	High.
33, 34, 35, 36 Pulantat	C	None	---	---	>180	---	---	25-51	Hard	Moderate	Low.
37**, 38**:											
Pulantat	C	None	---	---	>180	---	---	25-51	Hard	Moderate	Low.

See footnotes at end of table.

TABLE 13.--SOIL AND WATER FEATURES--Continued

Soil name and map symbol	Hydro-logic group	Flooding			High water table*			Bedrock		Risk of corrosion	
		Frequency	Duration	Months	Depth	Kind	Months	Depth	Hard-ness	Uncoated steel	Concrete
					Cm			Cm			
37**, 38**: Chacha	C	Rare	---	---	51-91	Perched	Jul-Dec	>102	Soft	Moderate	Moderate.
39**, 40**: Pulantat	C	None	---	---	>180	---	---	25-51	Hard	Moderate	Low.
Kagman	C	None	---	---	>180	---	---	>152	---	Moderate	Moderate.
41**, 42**: Pulantat	C	None	---	---	>180	---	---	25-51	Hard	Moderate	Low.
Urban land.											
43**, 44**: Ritidian	D	None	---	---	>180	---	---	5-25	Hard	Moderate	Low.
Rock outcrop.											
45**: Rock outcrop.											
Ritidian	D	None	---	---	>180	---	---	5-25	Hard	Moderate	Low.
46 Sasalaguan	C	None	---	---	>180	---	---	51-102	Soft	Moderate	Moderate.
47 Shioya	A	Rare	---	---	>180	---	---	>102	---	High	High.
48**, 49**: Togcha	B	None	---	---	>180	---	---	>152	---	Moderate	Moderate.
Akina	B	None	---	---	>180	---	---	51-102	---	Moderate	Moderate.
50**, 51**: Togcha	B	None	---	---	>180	---	---	>152	---	Moderate	Moderate.
Ylig	C	Occasional	Brief	Jun-Nov	25-102	Apparent	Jul-Nov	>152	---	High	High.
52. Troposaprists											
53**: Urban land.											

See footnotes at end of table.

TABLE 13.--SOIL AND WATER FEATURES--Continued

Soil name and map symbol	Hydro-logic group	Flooding			High water table*			Bedrock		Risk of corrosion	
		Frequency	Duration	Months	Depth	Kind	Months	Depth	Hard-ness	Uncoated steel	Concrete
					Cm			Cm			
53*: Ustorthents.											
54, 55------------ Ylig	C	Occasional	Brief-----	Jun-Nov	25-102	Apparent	Jul-Nov	>152	---	High-----	High.

* A plus sign preceding the range in depth indicates that the water table is above the surface of the soil. The first numeral in the range indicates how high the water rises above the surface. The second numeral indicates the depth below the surface.

** See description of the map unit for composition and behavior characteristics of the map unit.

TABLE 14.--CLASSIFICATION OF THE SOILS

Soil name	Family or higher taxonomic class
Agfayan	Clayey, montmorillonitic, isohyperthermic, shallow Udic Haplustolls
Akina	Very fine, kaolinitic, isohyperthermic Oxic Haplustalfs
Atate	Very-fine, kaolinitic, isohyperthermic Oxic Haplustalfs
Chacha	Very-fine, kaolinitic, isohyperthermic Oxic Haplustalfs
Chacha Variant	Very-fine, kaolinitic, isohyperthermic Typic Tropaqualfs
Guam	Clayey, gibbsitic, nonacid, isohyperthermic Lithic Ustorthents
Inarajan	Very-fine, mixed, nonacid, isohyperthermic Aeric Tropic Fluvaquents
Inarajan Variant	Very-fine, mixed, nonacid, isohyperthermic Tropic Fluvaquents
Kagman	Very-fine, kaolinitic, isohyperthermic Oxic Paleustalfs
Pulantat	Clayey, montmorillonitic, isohyperthermic, shallow Udic Haplustalfs
Ritidian	Clayey-skeletal, gibbsitic, nonacid, isohyperthermic Lithic Ustorthents
Saipan	Fine, mixed, isohyperthermic Oxic Haplustalfs
Sasalaguan	Very-fine, montmorillonitic, isohyperthermic Vertic Haplustalfs
Shioya	Carbonatic, isohyperthermic Typic Ustipsamments
Togcha	Very-fine, mixed, isohyperthermic Ultic Paleustalfs
Troposaprists	Troposaprists
Ustorthents	Ustorthents
Yigo	Clayey, gibbsitic, isohyperthermic Tropeptic Eutrustox
Ylig	Fine, mixed, acid, isohyperthermic Aquic Ustifluvents

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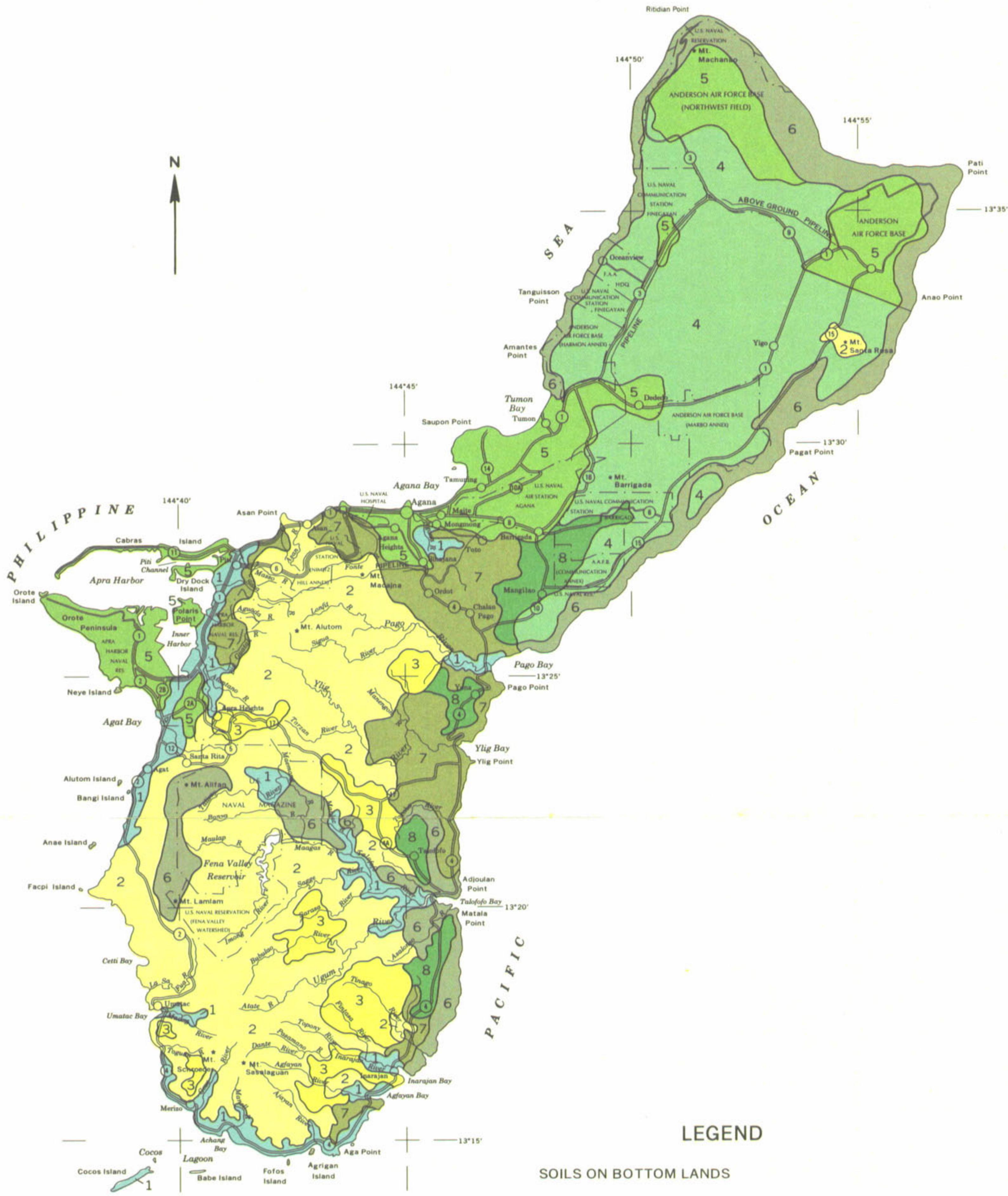
Each area outlined on this map consists of more than one kind of soil. The map is thus meant for general planning rather than a basis for decisions on the use of specific tracts.



LEGEND

SOILS ON BOTTOM LANDS

1 — Inarajan-Inarajan Variant: Deep and very deep, somewhat poorly drained and poorly drained, level and nearly level soils; on valley bottoms and coastal plains

SOILS ON VOLCANIC UPLANDS

2 — Akina-Agfayan: Very shallow to very deep, well drained, moderately steep to extremely steep soils; on strongly dissected mountains and plateaus

3 — Akina-Togcha-Ylig: Very deep, somewhat poorly drained and well drained, gently sloping to strongly sloping soils; on plateaus and in basins

SOILS ON LIMESTONE UPLANDS

4 — Guam: Very shallow, well drained, nearly level to moderately sloping soils; on plateaus

5 — Guam-Urban land-Pulantat: Very shallow and shallow, well drained, level to gently sloping soils, and Urban land; on plateaus

6 — Ritidian-Rock outcrop-Guam: Very shallow, well drained, gently sloping to extremely steep soils, and Rock outcrop; on plateaus, mountains, and escarpments

7 — Pulantat: Shallow, well drained, gently sloping to steep soils; on dissected plateaus and hills

8 — Pulantat-Kagman-Chacha: Shallow, deep, and very deep, somewhat poorly drained and well drained, nearly level to strongly sloping soils; on plateaus and hills

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UNITED STATES DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE
UNIVERSITY OF GUAM
GOVERNMENT OF GUAM
DEPARTMENT OF COMMERCE

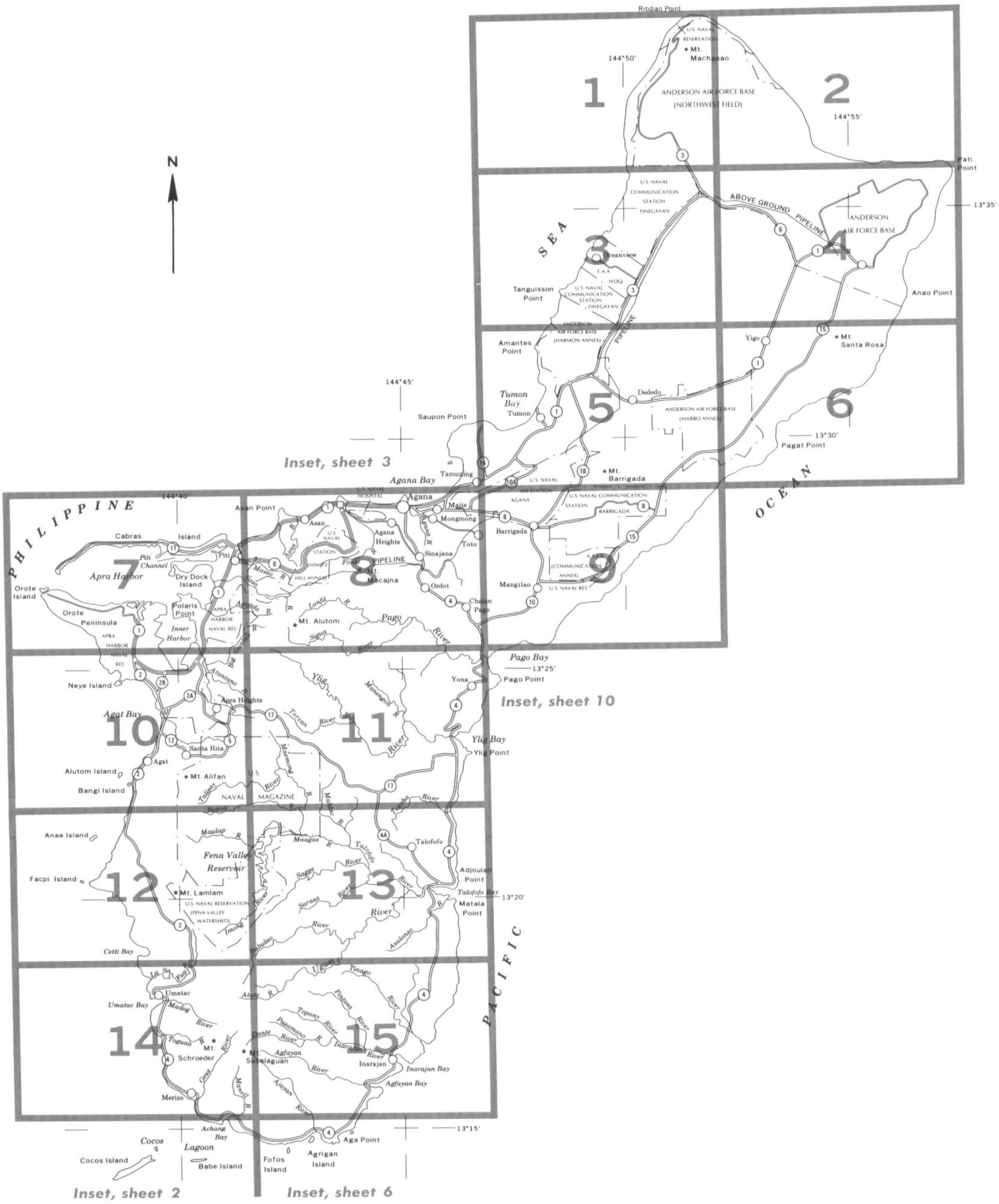
GENERAL SOIL MAP

TERRITORY OF GUAM

Scale 1:190,080

1 0 1 2 3 Miles

1 0 3 6 Km



INDEX TO MAP SHEETS

TERRITORY OF GUAM

Scale 1:190,080

1 0 1 2 3 Miles

1 0 3 6 Km

SOIL LEGEND

SYMBOL	NAME
1	Agfayan clay, 15 to 30 percent slopes
2	Agfayan clay, 30 to 60 percent slopes
3	Agfayan-Rock outcrop complex, 7 to 15 percent slopes
4	Agfayan-Rock outcrop complex, 15 to 30 percent slopes
5	Agfayan-Rock outcrop complex, 30 to 60 percent slopes
6	Agfayan-Akina association, extremely steep
7	Agfayan-Akina-Rock outcrop association, extremely steep
8	Akina silty clay, 3 to 7 percent slopes
9	Akina silty clay, 7 to 15 percent slopes
10	Akina silty clay, 15 to 30 percent slopes
11	Akina silty clay, 30 to 60 percent slopes
12	Akina-Agfayan association, steep
13	Akina-Atate silty clays, 0 to 7 percent slopes
14	Akina-Atate silty clays, 7 to 15 percent slopes
15	Akina-Atate silty clays, 15 to 30 percent slopes
16	Akina-Atate silty clays, 30 to 60 percent slopes
17	Akina-Atate association, steep
18	Akina-Badland complex, 7 to 15 percent slopes
19	Akina-Badland complex, 15 to 30 percent slopes
20	Akina-Badland complex, 30 to 60 percent slopes
21	Akina-Badland association, steep
22	Akina-Urban land complex, 0 to 7 percent slopes
23	Chacha clay, 0 to 5 percent slopes
24	Chacha Variant clay, 0 to 3 percent slopes
25	Guam cobbly clay loam, 3 to 7 percent slopes
26	Guam cobbly clay loam, 7 to 15 percent slopes
27	Guam-Saipan complex, 0 to 7 percent slopes
28	Guam-Urban land complex, 0 to 3 percent slopes
29	Guam-Yigo complex, 0 to 7 percent slopes
30	Inarajan clay, 0 to 4 percent slopes
31	Inarajan sandy clay loam, 0 to 3 percent slopes
32	Inarajan Variant mucky clay, 0 to 3 percent slopes
33	Pulantat clay, 3 to 7 percent slopes
34	Pulantat clay, 7 to 15 percent slopes
35	Pulantat clay, 15 to 30 percent slopes
36	Pulantat clay, 30 to 60 percent slopes
37	Pulantat-Chacha clays, 0 to 7 percent slopes
38	Pulantat-Chacha clays, 7 to 15 percent slopes
39	Pulantat-Kagman clays, 0 to 7 percent slopes
40	Pulantat-Kagman clays, 7 to 15 percent slopes
41	Pulantat-Urban land complex, 0 to 7 percent slopes
42	Pulantat-Urban land complex, 7 to 15 percent slopes
43	Ritidian-Rock outcrop complex, 3 to 15 percent slopes
44	Ritidian-Rock outcrop complex, 15 to 60 percent slopes
45	Rock outcrop-Ritidian complex, 60 to 99 percent slopes
46	Sasalaguan clay, 7 to 15 percent slopes
47	Shioya loamy sand, 0 to 5 percent slopes
48	Togcha-Akina silty clays, 3 to 7 percent slopes
49	Togcha-Akina silty clays, 7 to 15 percent slopes
50	Togcha-Ylig complex, 3 to 7 percent slopes
51	Togcha-Ylig complex, 7 to 15 percent slopes
52	Troposaprists, 0 to 1 percent slopes
53	Urban land-Ustorthents complex, nearly level
54	Ylig clay, 0 to 3 percent slopes
55	Ylig clay, 3 to 7 percent slopes
	Water

CONVENTIONAL AND SPECIAL SYMBOLS LEGEND

CULTURAL FEATURES

BOUNDARIES

- National, state or province
- County or parish
- Minor civil division
- Reservation (national forest or park, state forest or park, and large airport)
- Land grant
- Limit of soil survey (label)
- Field sheet matchline and neatline

AD HOC BOUNDARY (label) — Swift Airport

Small airport, airfield, park, oilfield, cemetery, or flood pool — FLOOD POOL LINE

STATE COORDINATE TICK

LAND DIVISION CORNER (sections and land grants)

ROADS

- Divided (median shown if scale permits)
- Other roads
- Trail

ROAD EMBLEM & DESIGNATIONS

- Interstate — 21
- Federal — 173
- State — 28
- County, farm or ranch — 1283

RAILROAD

POWER TRANSMISSION LINE (normally not shown)

PIPE LINE (normally not shown)

FENCE (normally not shown)

LEVEES

- Without road
- With road
- With railroad

DAMS

- Large (to scale)
- Medium or Small — water, w

PITS

- Gravel pit
- Mine or quarry

MISCELLANEOUS CULTURAL FEATURES

- Farmstead, house (omit in urban areas)
- Church
- School
- Indian mound (label) — Indian Mound
- Located object (label) — Tower
- Tank (label) — Gas
- Wells, oil or gas
- Windmill
- Kitchen midden

WATER FEATURES

DRAINAGE

- Perennial, double line
- Perennial, single line
- Intermittent
- Drainage end
- Canals or ditches
  - Double-line (label) — CANAL
  - Drainage and/or irrigation

LAKES, PONDS AND RESERVOIRS

- Perennial — water, w
- Intermittent — int, i

MISCELLANEOUS WATER FEATURES

- Marsh or swamp
- Spring
- Well, artesian
- Well, irrigation
- Wet spot

SPECIAL SYMBOLS FOR SOIL SURVEY

SOIL DELINEATIONS AND SYMBOLS — 18, 49

ESCARPMENTS

- Bedrock (points down slope)
- Other than bedrock (points down slope)

SHORT STEEP SLOPE

GULLY

DEPRESSION OR SINK

SOIL SAMPLE (normally not shown) — S

MISCELLANEOUS

- Blowout
- Clay spot
- Gravelly spot
- Gumbo, slick or scabby spot (sodic)
- Dumps and other similar non soil areas
- Prominent hill or peak
- Rock outcrop (includes sandstone and shale)
- Saline spot
- Sandy spot
- Severely eroded spot
- Slide or slip (tips point upslope)
- Stony spot, very stony spot

1

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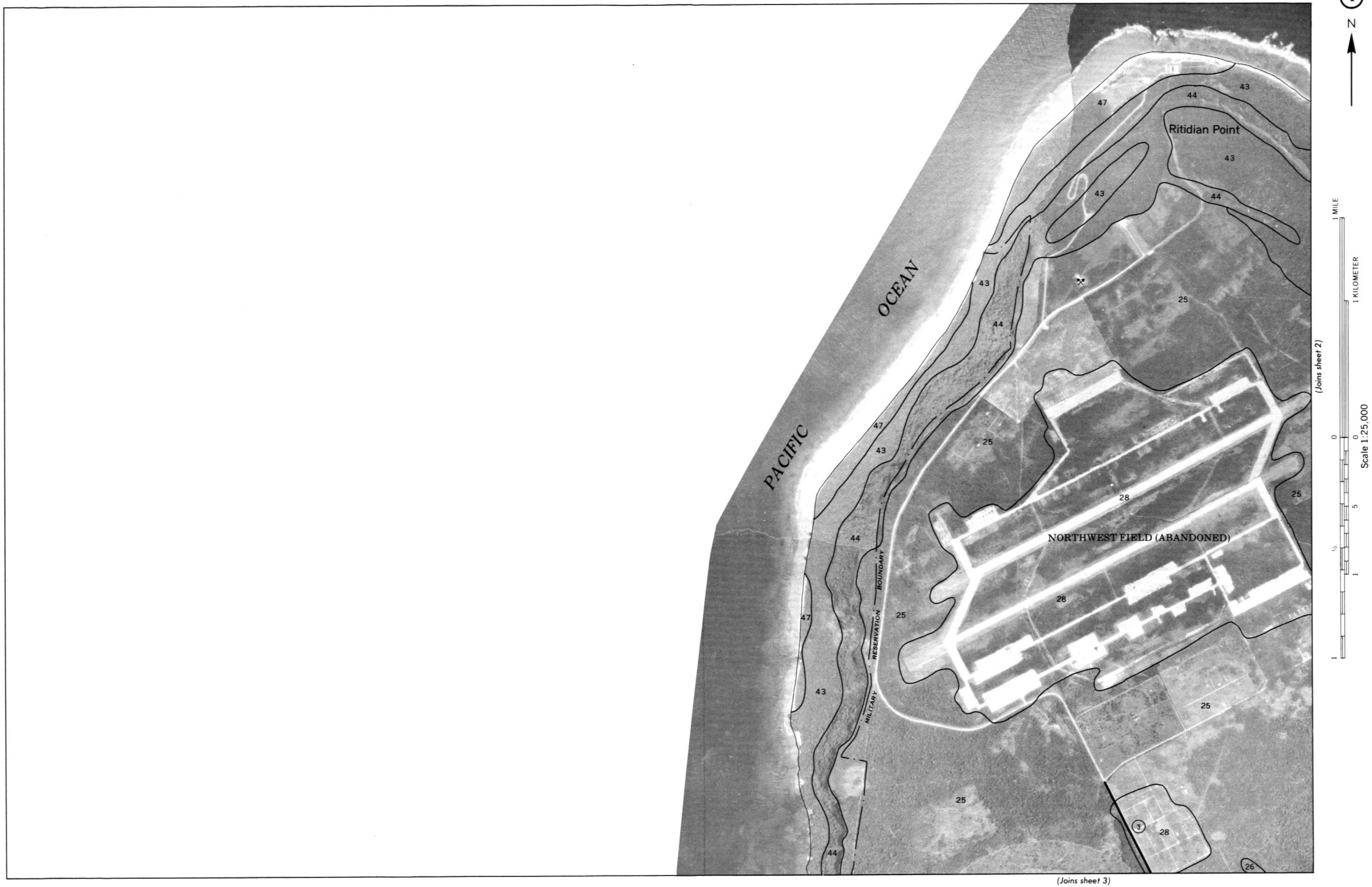
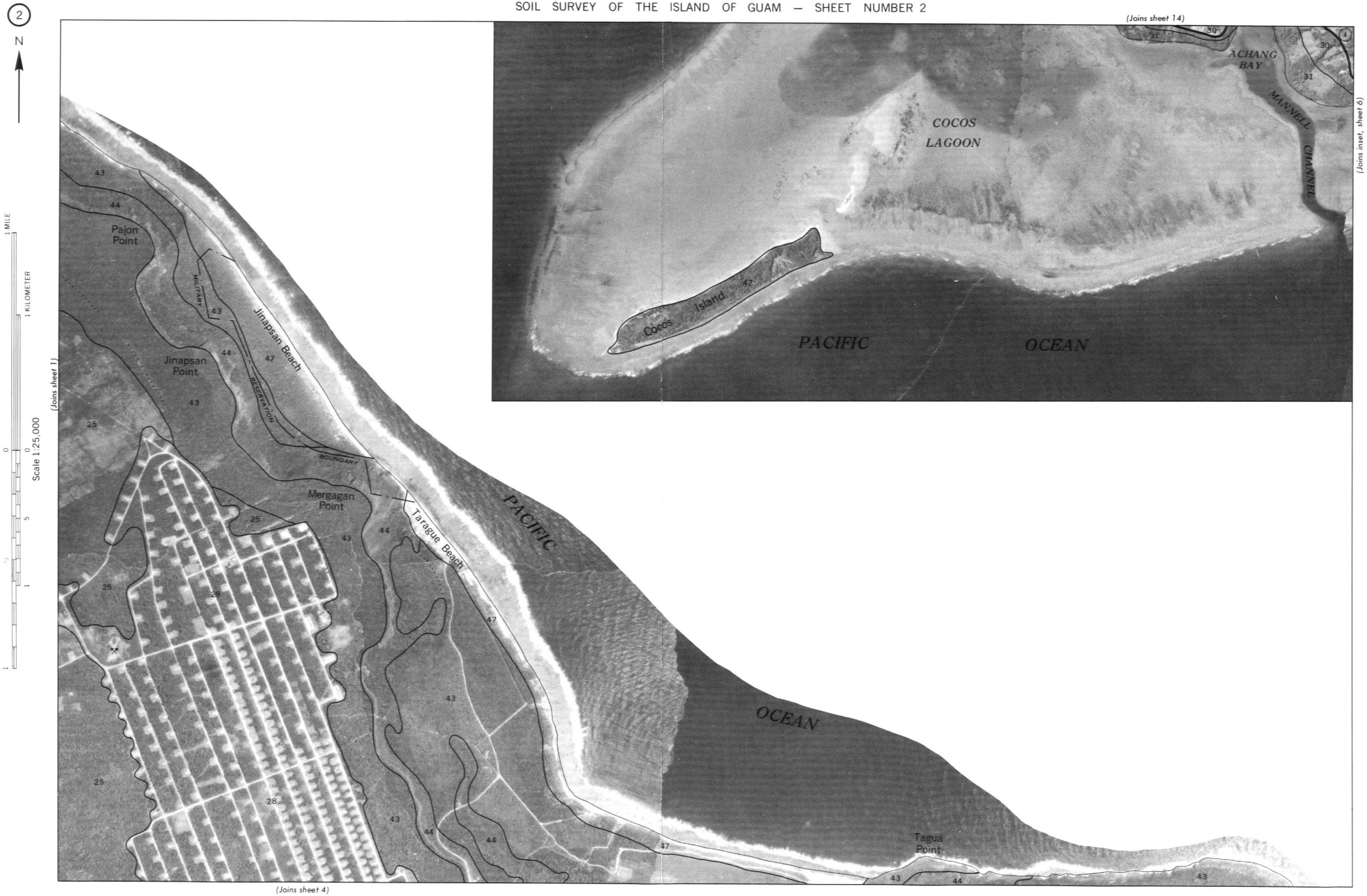
Photobase is an uncontrolled mosaic prepared from 1975 aerial photography.

ISLAND OF GUAM NO. 1





ISLAND OF GUAM NO. 2

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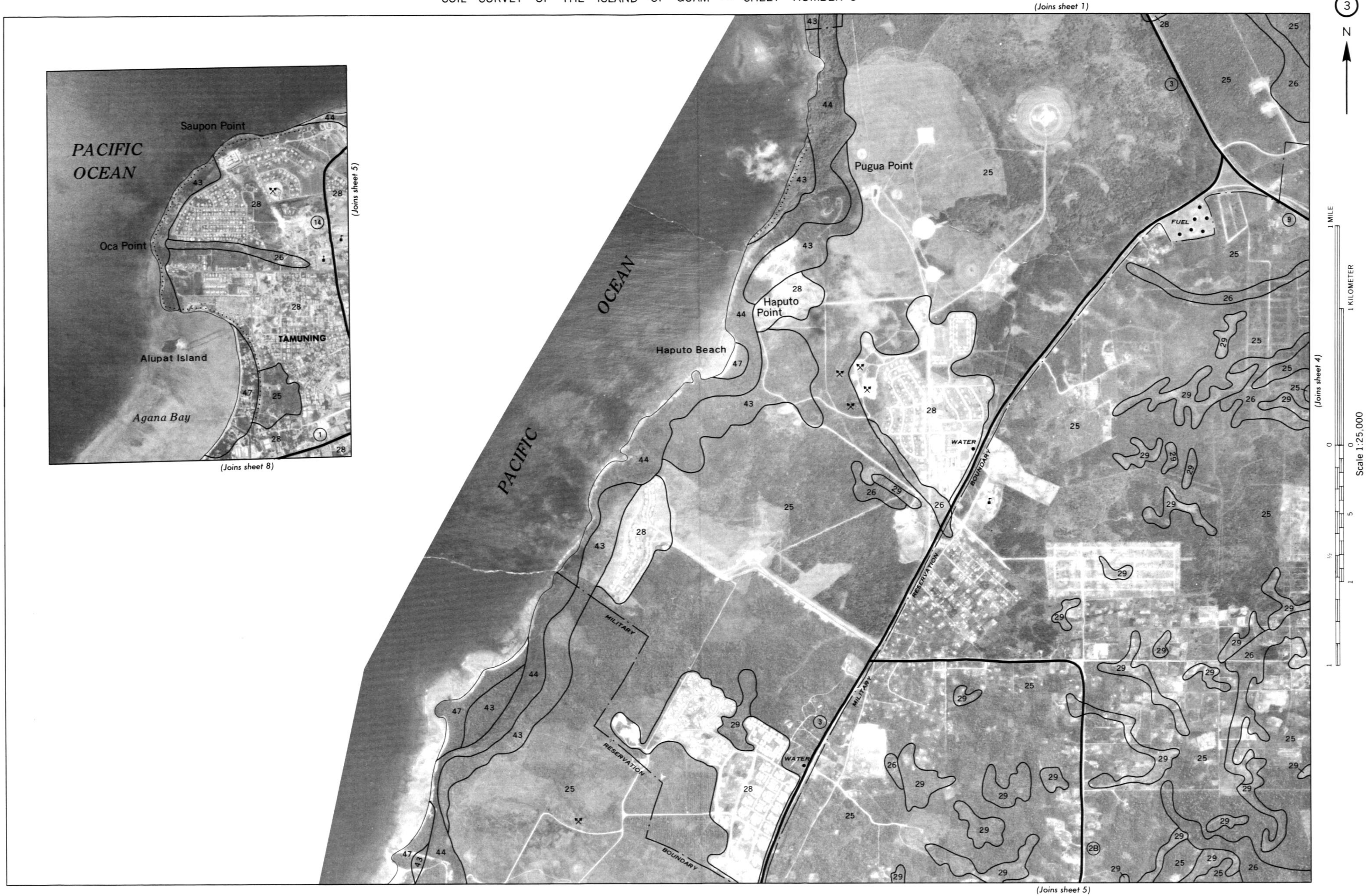

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ISLAND OF GUAM NO. 3

SOIL SURVEY OF THE ISLAND OF GUAM — SHEET NUMBER 4

ISLAND OF GUAM NO. 4

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SOIL SURVEY OF THE ISLAND OF GUAM — SHEET NUMBER 5

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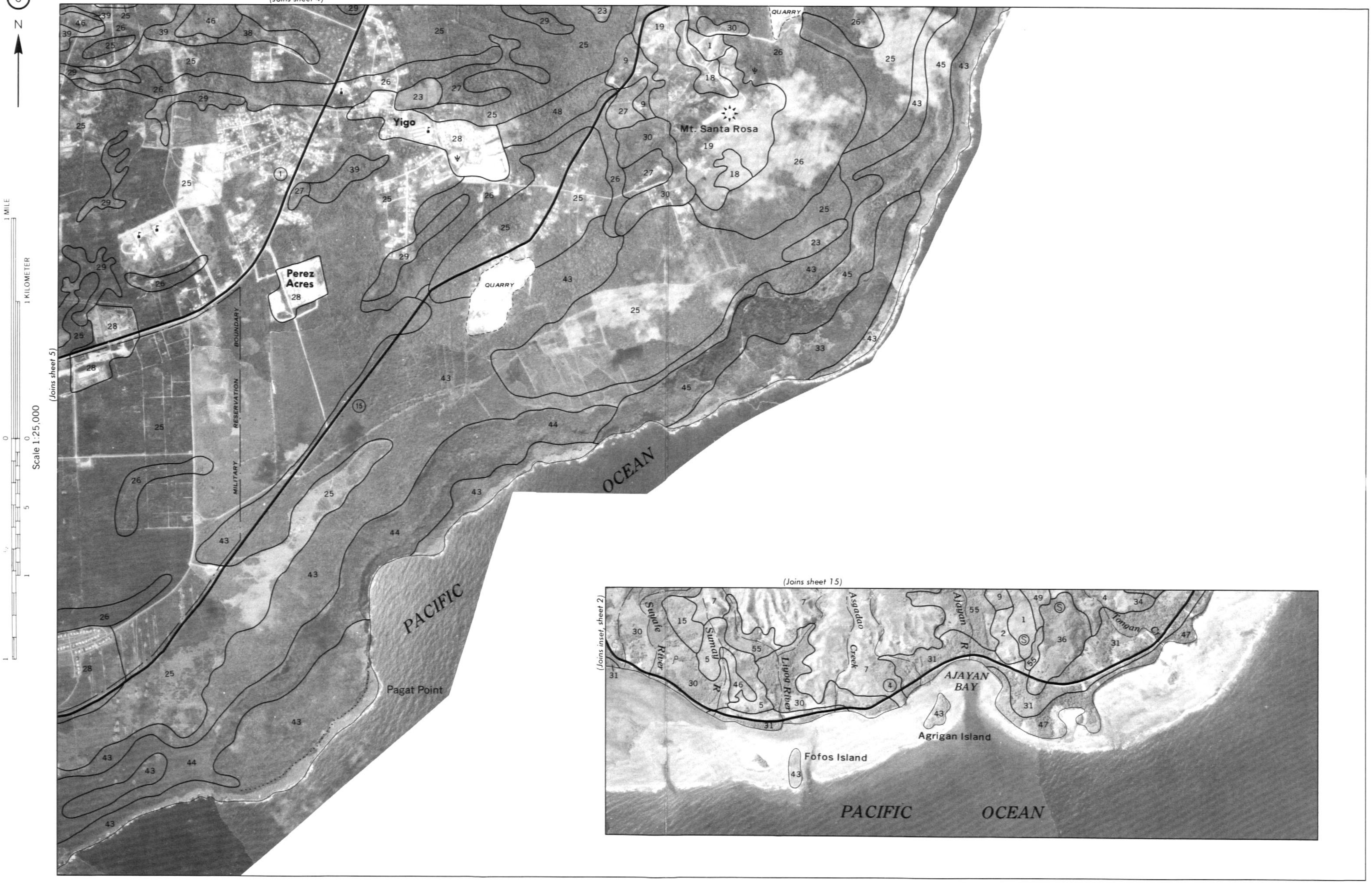
ISLAND OF GUAM NO. 5



ISLAND OF GUAM NO. 6

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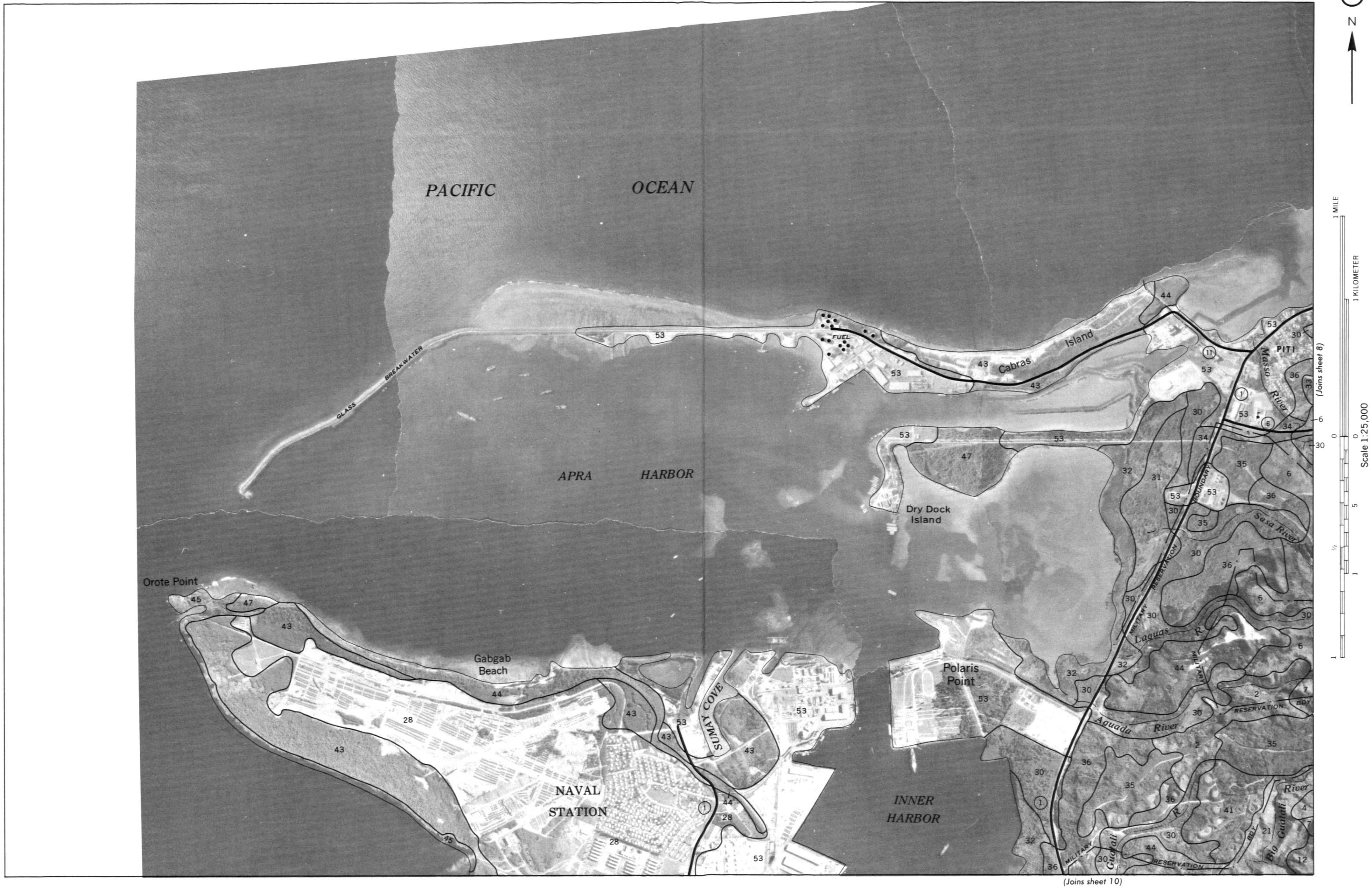
7



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ISLAND OF GUAM NO. 7

(8)

SOIL SURVEY OF THE ISLAND OF GUAM — SHEET NUMBER 8

N

(Joins inset, sheet 3)

(Joins sheet 7)

(Joins sheet 9)

(Joins sheet 11)

1 MILE

1 KILOMETER

Scale 1:25,000

ISLAND OF GUAM NO. 8

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SOIL SURVEY OF THE ISLAND OF GUAM — SHEET NUMBER 9

9

(Joins sheet 5)

(Joins sheet 8)

(Joins inset, sheet 10)

N

1 MILE

1 KILOMETER

Scale 1:25,000

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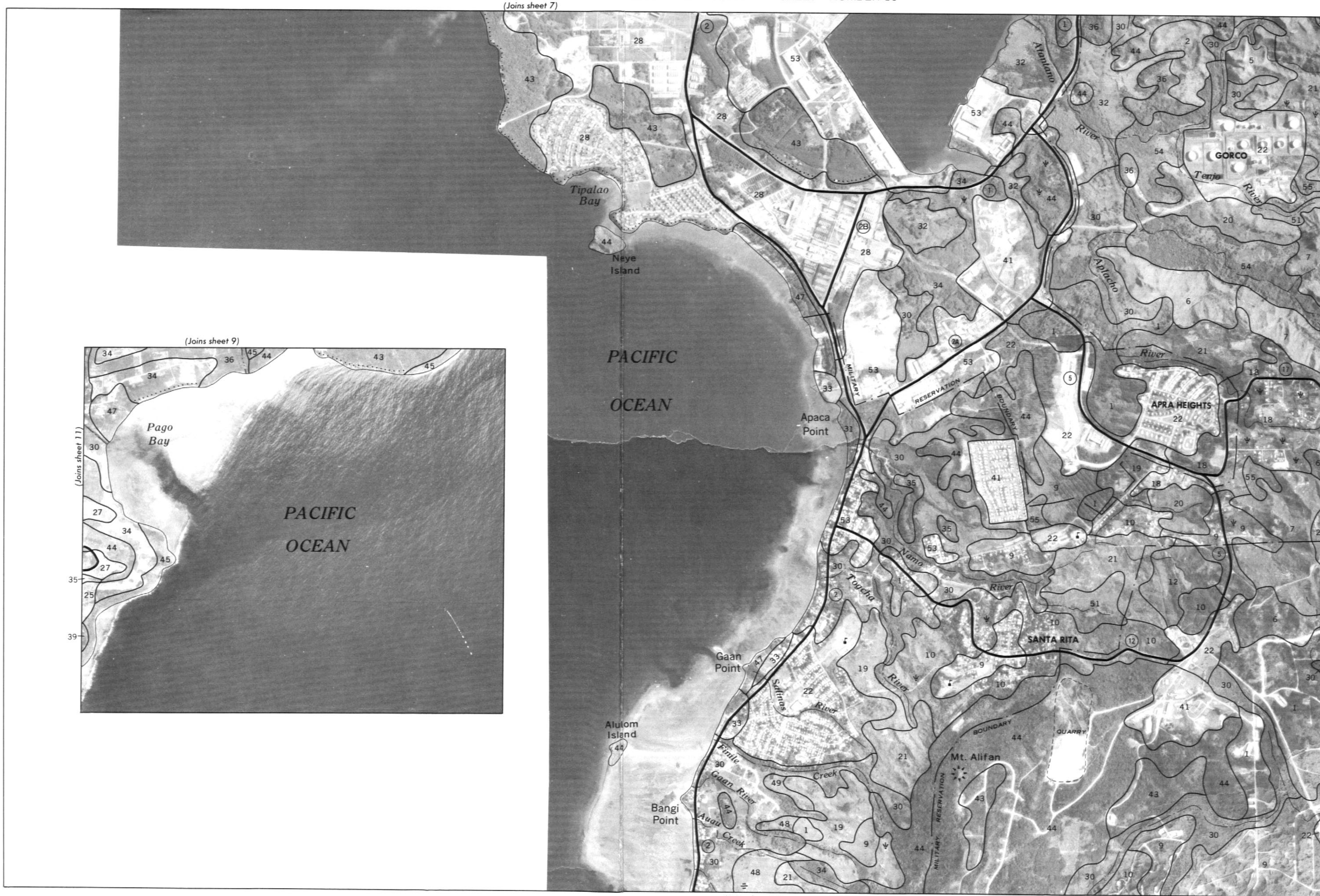
ISLAND OF GUAM NO. 9

SOIL SURVEY OF THE ISLAND OF GUAM — SHEET NUMBER 10

10

N



1 MILE
1 KILOMETER
Scale 1:25,000

ISLAND OF GUAM NO. 10
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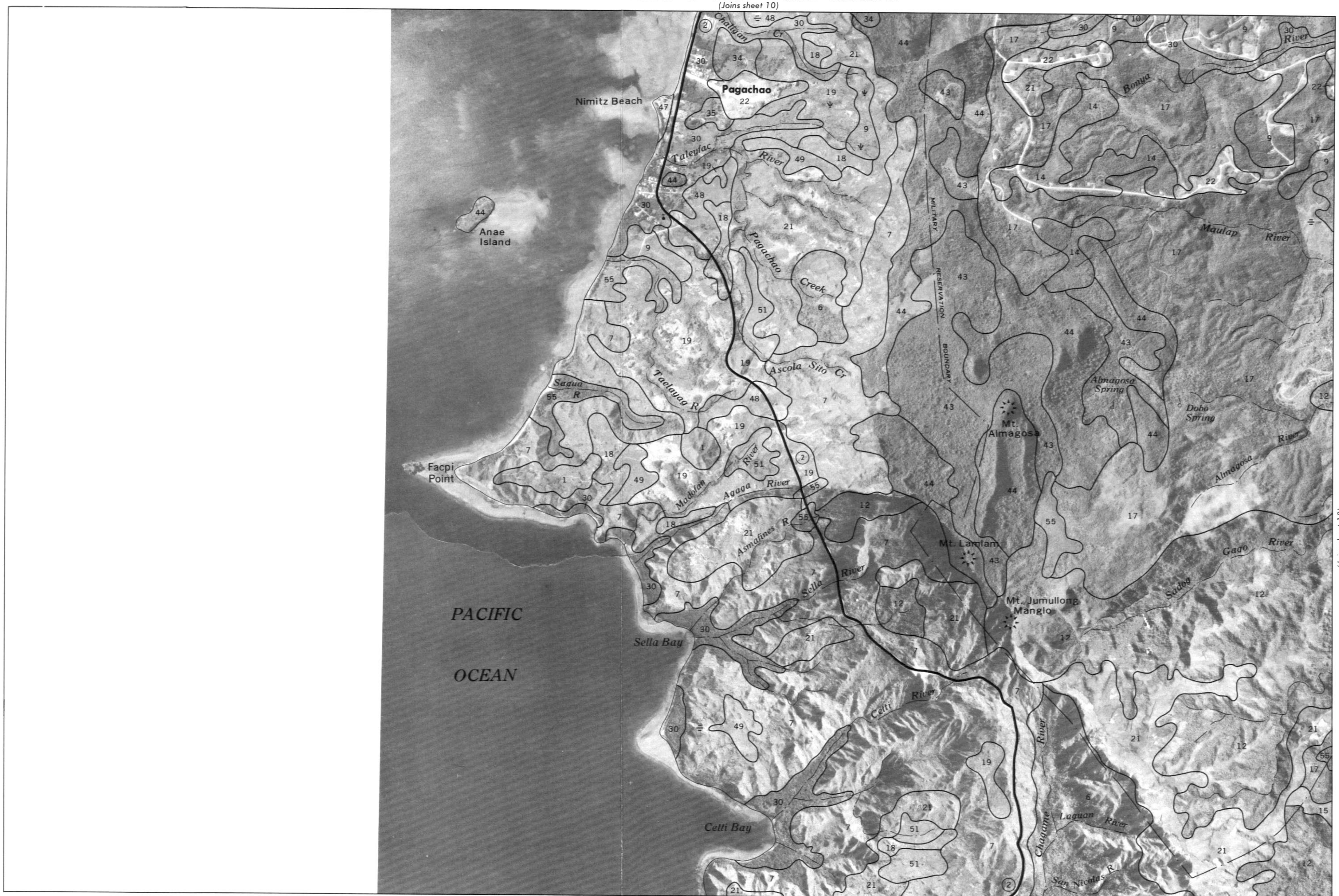
ISLAND OF GUAM NO. 11

12

N

(Joins sheet 10)



1 MILE

1 KILOMETER

Scale 1:25,000

(Joins sheet 13)

(Joins sheet 14)

ISLAND OF GUAM NO. 12

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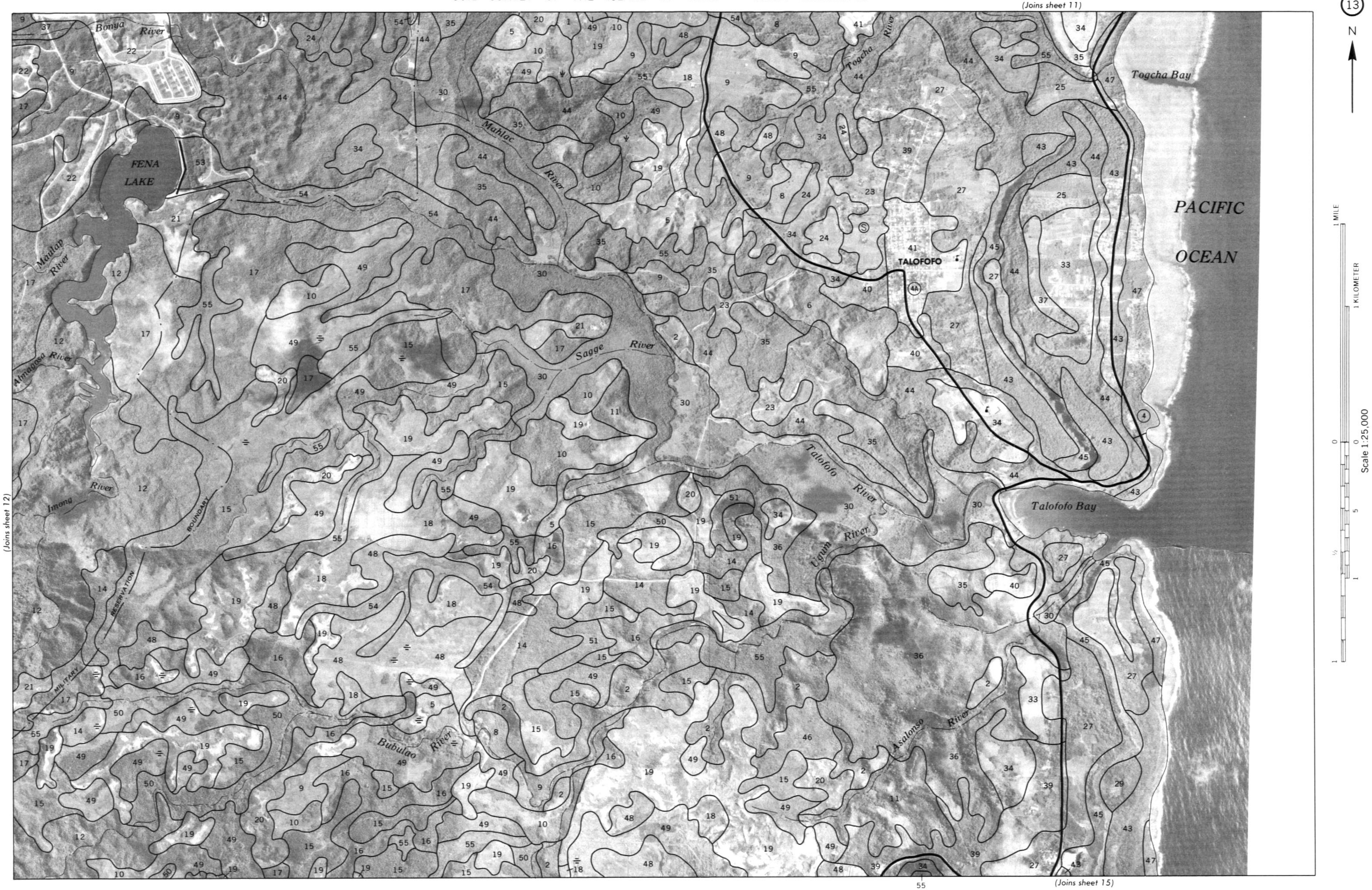

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ISLAND OF GUAM NO. 13

14

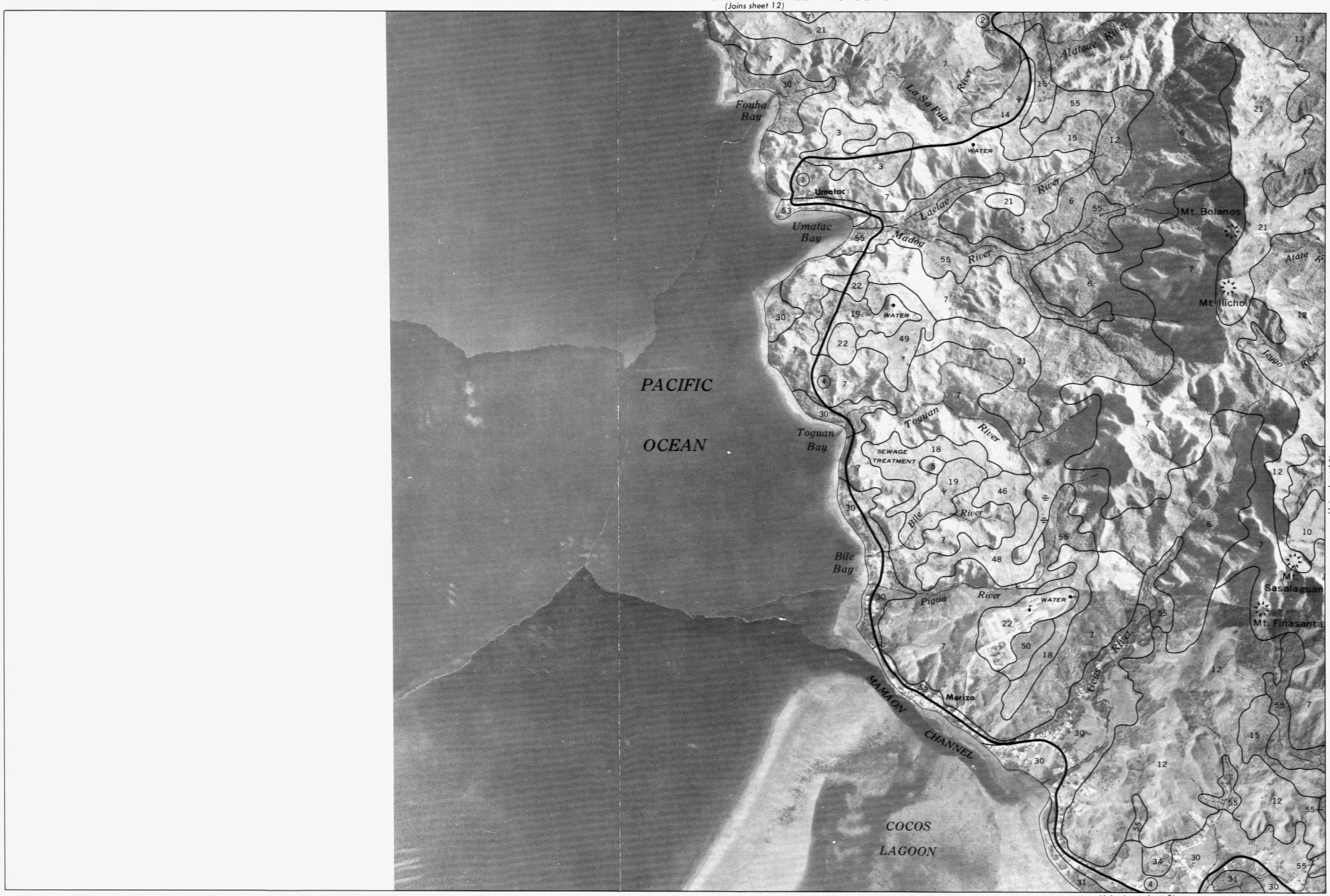
SOIL SURVEY OF THE ISLAND OF GUAM — SHEET NUMBER 14

N

Scale 1:25,000

1 MILE

1 KILOMETER



ISLAND OF GUAM NO. 14

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ISLAND OF GUAM NO. 15